COMPUTERS

Computers

MERIT BADGE SERIES

BOY SCOUTS OF AMERICA

BOY SCOUTS OF AMERICA • NEW BRUNSWICK, NEW JERSEY

Requirements

1. Tell what computers are and briefly describe their history. Tell what data processing is and how it is used.

2. Name the major components of a digital computer system and describe the function of one component in detail.

3. Build a simple model of one of the following that will help you to illustrate and explain its function in detail: (a) core storage; (b) drum storage; (c) disk storage.

4. (a) Describe the differences and uses of analog and digital computers.

   (b) Explain the Hollerith and Powers codes and their role in computers.

5. Obtain your local post office ZIP code and convert to binary.

6. Using the flowchart diagram method, show the steps necessary to set up a campsite.

7. Name four different uses of computers.

8. Convert your full name to each of the following codes: (a) Hollerith; (b) binary-coded decimal; (c) eight-channel standard code.

9. Be able to tell your merit badge counselor in your own words the meaning of the following words or terms:

Functional units	Information retrieval
Storage	Solid-state components
Input and output devices	Nanosecond
Random access	Stored program
On-line system	Console
Central processing unit	Optical reader
Magnetic ink characters	Register

10. Do two of the following:

   (a) Arrange with your counselor to visit a local computer installation.

   (b) Obtain and read two pieces of information about computers other than manufacturer's literature. Summarize what you read for the counselor.

   (c) Write a 500-word report on the various types of specialist occupations available in the computers field. Include educational requirements and average wage brackets, when possible.

   (d) Show your counselor five examples of data-processing output or the tape, cards, or report forms used.

11. (a) Construct an analog adder and explain its operation.

   (b) Construct a card reader, demonstrate it to your merit badge counselor, and explain to him the difference between the Hollerith card code and the internal machine code.

Contents

Computers in Your Life

When you were a small boy, you may have tried to find out what you were going to become by playing a little game with yourself. You jumped rope or tried to step on cracks in the sidewalk, while reciting a little rhyme that went something like this:

Rich man, poor man, merchant, thief, doctor, lawyer, Indian chief.

The word you were on when you missed a jump or a crack in the walk told you what you would be when you grew up.

No matter what career you choose, it's safe to say that computers will play a big role in your life when you become a man.

The computer touches the life of nearly every American today, at least in the way he is paid for work or spends his money. By the time you are a man, the computer will have thousands of new uses. Almost certainly computers will enter directly into your business, trade, or profession in some way.

While you have been reading this page, a single electronic computer somewhere has been doing *tens of millions* of mathematical calculations. Another has translated several pages this size from English into a foreign language. A third has confirmed a reservation in a Chicago ticket center for a man who wants to take a certain flight from Miami to San Francisco, reporting that there will be room on the plane for him. And another may have composed several bars of music!

As you earn your Computers merit badge, you will find out what these machines can do now, how they work, and what they mean to you as you grow up.

Computers of the past
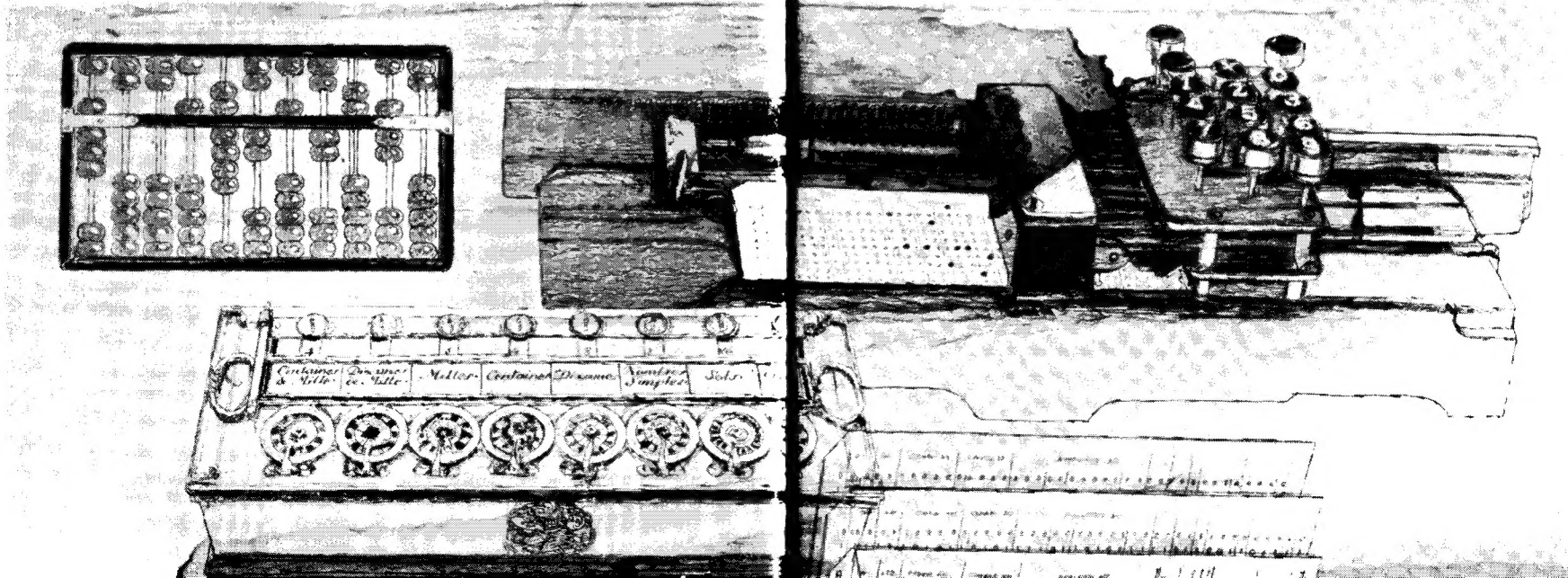
What Is a Computer?

1. Tell what computers are and briefly describe their history. Tell what data processing is and how it is used.

In its broadest meaning, a computer is anyone or anything that computes or figures out a problem. Thus, when you are working on an arithmetic problem, you are a computer.

But the meaning of the word used throughout this booklet is much more restricted. We will talk about computers using this definition: "Any device capable of accepting data, applying prescribed processes to them, and supplying the results of these processes."

Ancient man's first computer was his fingers and toes. When the problems began to involve numbers over 20, the Stone Age merchant used pebbles or seashells to count with.

The first true computer was the abacus, still used in some countries today. It was in use no later than 450 B.C., and perhaps much earlier. The abacus consists of several strings of beads on wires strung in a rectangular frame. Each bead represents a digit, or number from 0 to 9, and the operator calculates by moving the beads on the wires. A skillful operator can do arithmetic using an abacus with amazing speed.

Now let's look at the history of the computer since the invention of the abacus.

1642 France • The first mechanical computer, an adding machine, was invented by the French philosopher and mathematician Blaise Pascal. It worked much the same as modern desk adding machines. The digits from 0 to 9 were engraved on several wheels. The first wheel represented 0 to 9, the second the tens, the third the hundreds, etc. If the operator wanted to "store," say, 136 in the machine, he would turn the third wheel to 1, the second to 3, and the first to 6. If he wanted to add 5 to this figure, he turned the first wheel five places. Through a series of gears, this action turned the second wheel for a new total of 141.

1671 Germany • Gottfried Wilhelm von Leibnitz, a German philosopher and mathematician, designed a more advanced calculating machine that could multiply as well as add.
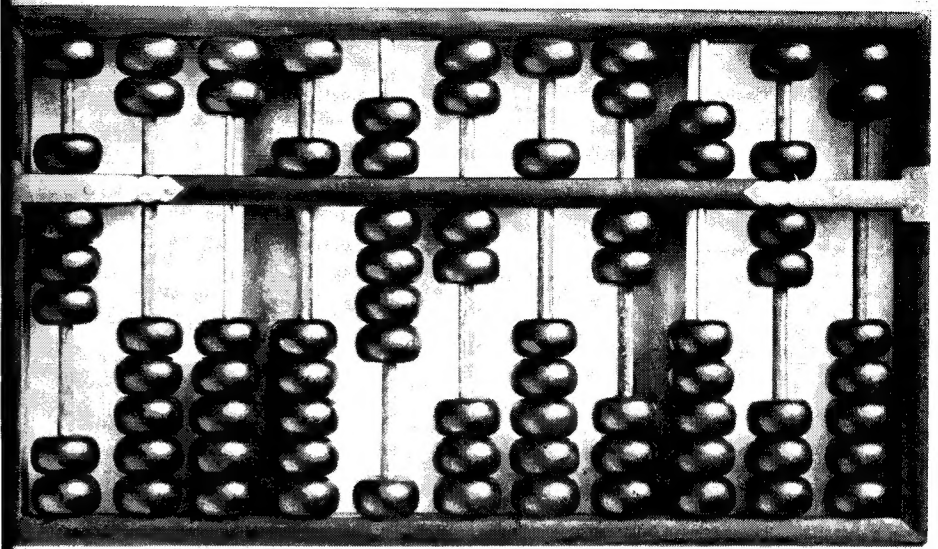
The abacus
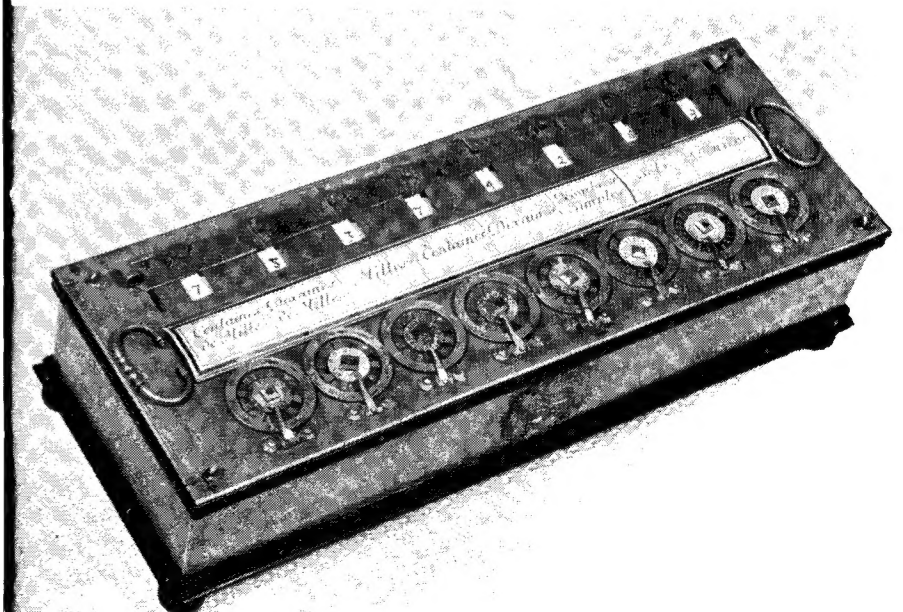
Pascal's calculator

1801 France • A weaver named Joseph M. Jacquard had an idea for automating the loom by using a punched card, the basis for the first modern computers. Making patterns in cloth was very costly, and Jacquard got the idea of guiding the needles at each pass of the shuttle by allowing only the ones he wanted to pass through a card with holes punched in it. Very intricate patterns could be made cheaply by this early automated loom. The same principle is still used in many modern data-processing computers of the kind used in business.

1822 England • Charles Babbage, a scientist and inventor, designed a "difference engine," basically an adding machine that could compute logarithms—numbers universally used in higher mathematics. In 1833, Babbage conceived the idea for his "analytical engine," a device he expected would perform any arithmetic problem and string such calculations together. He borrowed the punched card idea from Jacquard and planned to use it to set up problems for the engine. In effect, Babbage had designed the forerunner of the modern computer. It would have been much slower, handling only about 60 calculations a minute, because it was mechanical rather than electric. Because of technical and financial difficulties, Babbage's "analytical machine" was never completed although he devoted the remaining 40 years of his life to it.

1889 United States • Dr. Herman Hollerith, a statistician from Buffalo, N. Y., developed the Hollerith punched card and card machine, which used electricity and thus was the first electric computer. It was first used in the census of 1890. The method was to float each of the coded punched cards with the data about one American across a pool of mercury. Telescopic pins overhead dropped through the holes. When a pin touched the mercury, it made an electrical contact and one more fact about an American was recorded. To exploit his invention Hollerith formed a company which, after a merger, became International Business Machines Corp. (IBM).

1944 United States • Dr. Howard H. Aiken, a Harvard professor, and four IBM engineers completed the Mark I, an electromechanical computer that could follow a series of instructions.

1946 United States • The first electronic computer was completed by Dr. J. Presper Eckert and Dr. John Mauchly at the University of Pennsylvania. It was

Dr. Herman Hollerith
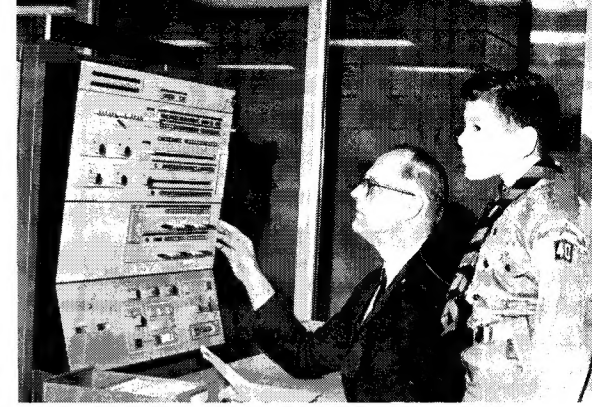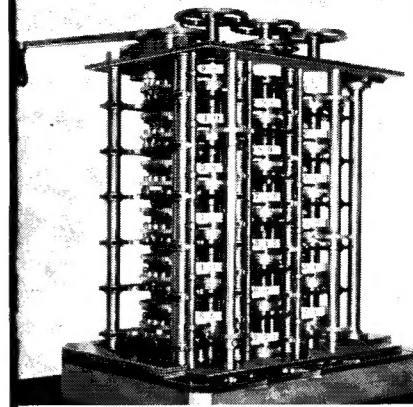
Babbage's difference engine is shown at left, and modern computer console, right

called ENIAC for Electronic Numerical Integrator and Computer and used vacuum tubes in place of the electrically controlled mechanical parts in the Mark I. Parts of it are now in the Smithsonian Institution.

1949 England • The EDSAC (Electronic Delay Storage Automatic Calculator) was completed at the University of Cambridge. It was the first computer that could "store" a series of instructions from one year to the next, if necessary.

1950 United States • The EDVAC (Electronic Discrete Variable Automatic Computer) was put into use at the Army's Aberdeen Proving Grounds in Maryland. Like the EDSAC, it was a stored-program computer.

1951 United States • The UNIVAC I, produced by the Sperry Rand Corp., was the first commercially produced computer.

Present • There has been no great change in scientific principles in computers since the EDSAC and EDVAC. Transistors and other technological advances have greatly increased the speed and lowered the costs of electronic computers, but the basic principles are the same as in these earlier machines.

A large modern computer unit setup

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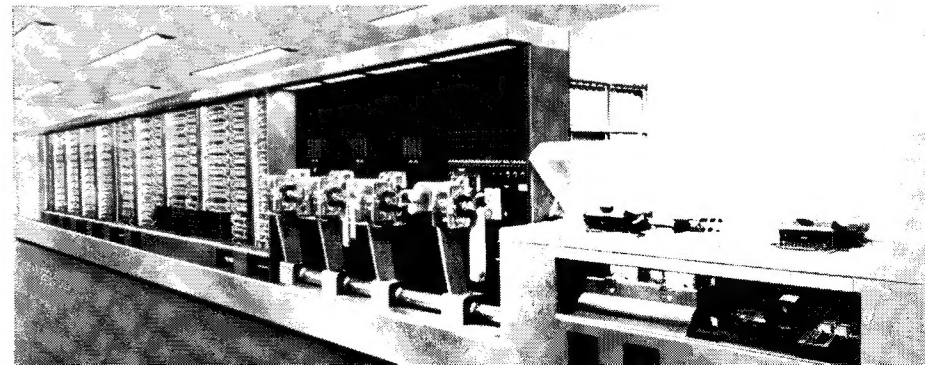
What Is Data Processing?

Executives base their business decisions on information, or *data*, such as operating costs, inventory levels, sales and manufacturing statistics, and so on. Other things being equal, the man with the greatest amount of accurate business data at his command has the greatest competitive edge over his business rivals.

However, like raw foods or raw materials, raw data are of limited use. Only when these data are examined, compared, and analyzed do they take on real value, just as raw materials take on real value through manufacturing. This is what we mean by *data processing*.

A data-processing *system*, then, is a group of people and/or machines organized to work together to perform the data-processing requirements of an organization.
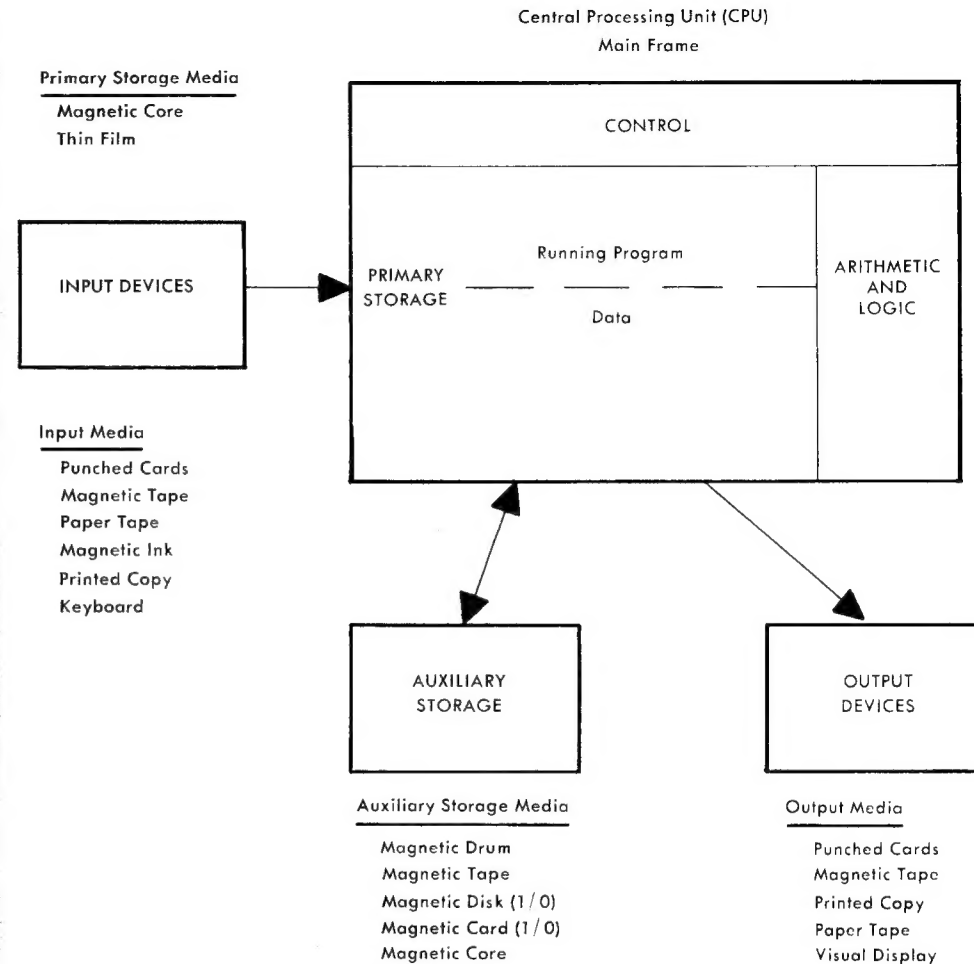
In one manner or another, businessmen always have referred to available data as a business guide. But unfortunately, they never have been able to use it as fully or wisely as they might wish, due to the time and expense required in gathering data and analyzing it.

More recently, various types of business machines—notably the electronic computer—have taken over this task, thereby providing more valuable business data upon which to base decisions, faster and less expensively than ever before. With more data and faster and more reliable interpretation of data, much of the guesswork and uncertainty of decision-making is being reduced or eliminated.

The concept of data processing involves the manipulation of facts and figures—according to a prearranged plan—to produce new, more desirable information. The practice of data processing ranges from mental arithmetic to the complex of intricate scientific or engineering problems, but it always involves three operations:

1. Input—the gathering and introduction of information to be analyzed.

2. Processing—the manipulation of this data according to plan.

3. Output—the production and distribution of results in a usable form.

Central Processing Unit (CPU)
Main Frame

Primary Storage Media
Magnetic Core
Thin Film

CONTROL

INPUT DEVICES

PRIMARY STORAGE

Running Program

Data

ARITHMETIC AND LOGIC

Input Media
Punched Cards
Magnetic Tape
Paper Tape
Magnetic Ink
Printed Copy
Keyboard

AUXILIARY STORAGE

OUTPUT DEVICES

Auxiliary Storage Media

Magnetic Drum
Magnetic Tape
Magnetic Disk (1/0)
Magnetic Card (1/0)
Magnetic Core

Output Media

Punched Cards
Magnetic Tape
Printed Copy
Paper Tape
Visual Display

Consider the problem of preparing a gas bill. Gas is furnished to the consumer, at his demand, but metered in such a way that the supplier can tell how much each customer has used. At periodic intervals, this information is recorded by means of reading the figures indicated on the meter. Past readings are deducted from current readings to determine the amount of gas used during the present billing period. This amount is multiplied by the utility's rate to obtain a billing figure. In some instances, discounts may have to be

calculated, but, in any event, the customer's bill is prepared and mailed.

In this example, the *input* is the past reading of the customer's meter and the current reading on that meter. *Processing* is involved in subtracting the one reading from the other, in multiplying the result by the unit rate, and, possibly, in computing certain discounts or allowances. The *output* is the customer's bill and the corresponding record the utility must maintain until the bill has been paid.

These same procedures must be followed whether the customer's bill is computed by pencil, calculating machine, or computer. Similar procedures are followed in every example of data processing.

In the same manner, certain other common elements also are present:

1. Arithmetic—used in the performance of a calculation.

2. Memory—to hold the information that is in process.

3. Control—the ability to determine what is to be done with the data at each stage of processing.

Naturally, there has to be communication between input, processing, and output. In the case of the gas company we've talked about, or any other business that uses a computer to do accounting and billing, there also has to be a way of carrying over the output to the next billing period. In old-fashioned accounting, this carry-over would be done by hand, transferring the balance owed, total purchases, etc., in pen and ink, to the next month's record.

With a computer, the output information becomes input again, and this is called feedback or turnaround. It provides control over the system.

A typical public utility bill prepared by computer

How a Computer Works

2. Name the major components of a digital computer system and describe the function of one component in detail.

There are two basic types of computers: analog and digital. We will consider the differences between the two types in Requirement 4a in some detail. The digital computer is much the more popular because it has the most applications. It is used in data processing (the handling of payroll records, store accounts, and many other types of recordkeeping) as well as in scientific and engineering calculations. When you hear the word "computer," chances are you are thinking of a digital computer that you may have seen in a bank or your dad's office.

The analog computer is widely used in industry to measure quantities and speeds. Put briefly, the difference between the two calculators is: the digital computer counts; the analog computer measures.

This requirement asks for the major components of a digital computer. There are five of them, as follows: *Input, Control, Processing (Arithmetic or Logic Unit), Storage or Memory*, and *Output*.
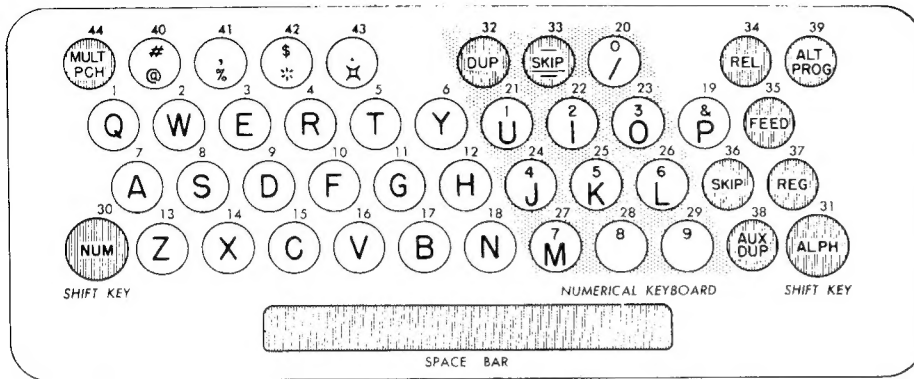
Each of these components is made up of very complex mechanical and electronic parts.

Input

The input mechanism is the device for putting data and instructions into the computer. It is the link between the human programmer and the machine.

There are a number of ways to establish this link. An early one still very popular is the punched card. Chances are your dad's electric or water bill is a punched card. When he pays the bill, this punched card is fed into a digital computer that keeps the utility's accounts. (The cards, by the way, are punched manually or by automatic machines that can handle more than 100 cards a minute. In a manual punching operation, a person called a keypunch operator runs a machine that works much like a typewriter except that it punches holes instead of printing letters and num-

This machine prints
data directly from
computer information.

CASH REQUIREMENTS STATEMENT

VENDOR ABBREVIATION	VENDOR NUMBER	DUE DATE MO.	DUE DATE DAY	DISCOUNT	INVOICE AMOUNT	AMOUNT TO PAY	TOTAL BY DATE
ABBOT BRASS	1179	12	31	318	15878	15560	
ABBOT BRASS	1179	12	31	196	9813	9617	
ABRAMS COAL	1180	12	31	831	27735	26904	
ABRAMS COAL	1180	12	31	1050	30000	28950	
BARR MACH	3076	12	31	15077	301527	286450	
EL TRUST CO	2052	12	31		5125	5125	
KARTAGE INC	4486	12	31		21875	21875	
LEHIGH COAL	4867	12	31	1384	69178	67794	
MAIZE REF	5809	12	31		11823	11823	
N MILT SUPP	6003	12	31		21415	21415	
N Y GAS EL	6122	12	31		67595	67595	
STATE N Y	7421	12	31		179286	179286	
W COR TEL	8146	12	31		23729	23729	
WICKWIRE BR	8634	12	31		36043	36043	
WISELO INC	8821	12	31		19518	19518	

Punched cards can be used to produce billing information.

bers.) Other ways of handling input are also used, especially in scientific work. Paper tape is often used. The tape has coded holes, as do punched cards, but the advantage is that a long series of data can be put on paper tape. Magnetic tape is also used. It is similar to the tape for a tape recorder. Its advantage over paper tape is that it can be edited or changed easily and holds more information.

Some computers can "read" directly from a printed paper. For example, the post office uses computers that can read addresses if they are typewritten and thus sort the mail automatically. Even more advanced machines are being developed that will "listen" to the programmer and take instructions directly from his voice.

Whatever the input process, the computer receives the data and translates it into "machine talk" or code. The data then go to the storage unit.

Punched tape input

Control

Before we put a problem to a computer, we must tell it what to do. This is done through the control unit.

The control unit must be told to start and stop, add, subtract, find a square root, file the information, or multiply. In other words, before we give the computer a problem, the machine must be told what is to be done and in exactly what order it should be done. It is given these instructions by the programmer.

Some relatively simple computers have programs "wired-in." That is, their circuits are fixed so that they can handle only one operation. This type is used for many automated processes. Others are extremely complex and flexible enough to solve any type of difficult mathematical problem.

Processing (Arithmetic or Logic Unit)

We have a problem prepared for input and a set of instructions for control. The data goes in at input and is sent to storage. Control takes over to route it properly and then the processing of the data begins in the arithmetic or logic unit.

We have said that when a computer receives data from input or instructions from control, it translates them into "machine talk." This is simply a series of electrical impulses flowing through the computer at high speed.

The key to the working of an electronic digital computer is found in the nature of electricity. Electrical
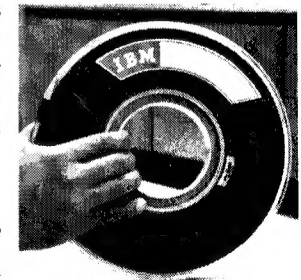
Magnetic tape input

current is either on or off. (See illustration top of page 17.) When you press the light switch, the bulb goes off. There is no in-between. This on-off characteristic of electricity is called a binary mode. The prefix bi-, as you know from the word bicycle, means two.

In mathematics, binary indicates arithmetic based on just two digits—0 and 1. Most modern computers use binary arithmetic, with 0 and 1 being combined to represent all numbers in the decimal system.

Here is the way the binary numbering system compares with the decimal:

Decimal	Binary	Decimal	Binary
0	0	5	101
1	1	6	110
2	10	7	111
3	11	8	1000
4	100	9	1001

Note that each succeeding number is the next smallest number that can be made with the digits 0 and 1.

This is called pure binary, and it is used in feeding numbers to some computers, especially in scientific and other special work. Most computers, however, use variations of this code, because it is necessary to have letters as well as numbers in the code. We will examine a few of these codes later.

The important thing to remember is that most electronic digital computers are functioning in a binary mode, no matter what code they are fed. The computer makes the translation to pure binary, whatever kind of information it is fed.

Using binary digits in working with the computer may seem a terribly complicated procedure, but in fact it simplifies the work of the computer. If the computer used decimal digits (0 to 9), it would have to be much bigger because it would need many more parts to work with the digits from 2 to 9.

With binary system, when a pulse is transmitted, the computer records a 1; when no pulse is transmitted, it records a 0. Since it is handling these two digits at speeds of millions per second, the fact that three digits must be used to express "5" for example, is no handicap to the computer. See photo bottom of page 17.

*Note: See your *Electronics* merit badge pamphlet for more information on how computers count.
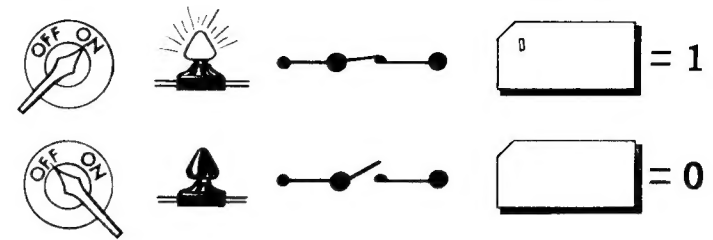
How binary numbers are expressed electrically


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0101000111000010101010001010101010
1101101110010010001111110101101010
1111010001011011011110001010111001
0101110111000010111000001111010101
0111110001010110011001110010101 1 1
0110001110101010110111010110101 01
0111110000110101010101111101010101
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Binary output

But we know that computers can solve problems other than arithmetic. They can handle questions of logic, too; that is, any question that can be solved by principles of reasoning. How do computers do that if all they can do is manipulate the digits 0 and 1?

They can do it because we change the binary terms the computer is working with. Instead of feeding the computer a series of 0 and 1 digits, we feed it questions of true or false, yes or no, and/or. If we then ask logical questions and provide the proper information, the computer selects the right answers to our many complex problems of logic.

Let's see how this works with three very simple problems of logic. Suppose we are using a computer, consisting of a battery, wires, some switches, and a bulb, to find out whether Joe is going to be at the troop meeting tonight.

Joe says, "I am going to the troop meeting tonight, if I finish my homework and household chores." On our computer, the problem would look like Diagram A, page 19.

Both No. 1 and No. 2 switches represent AND. *Both* must be closed to light the bulb that tells us Joe is going to the troop meeting. Joe is going if he does his homework AND his chores.

On the day of the next troop meeting, Joe Tenderfoot says, "I am going to the troop meeting if I finish my homework or household chores." On our computer the problem looks like Diagram B.

Both switches here represent *OR*. If either one is closed, the bulb will light, telling us that Joe will be at the troop meeting.

Now, suppose for the third troop meeting Joe says, "I am going to the troop meeting tonight if I finish my homework and chores, and if Sam or Dick comes to pick me up." This is a slightly more complex problem. On our computer it looks like Diagram C.

Switches No. 1 and No. 2 are *AND* switches. They represent Joe's homework and chores. He can't go without doing them. But he must also get a ride from either Sam or Dick or he won't go. Sam and Dick are represented by the *OR* switches, Nos. 3 and 4. To light the bulb, switches 1 and 2 plus *either* 3 or 4 must also be closed.

Through this method of and/or choice, the computer can solve much more difficult problems of logic because,
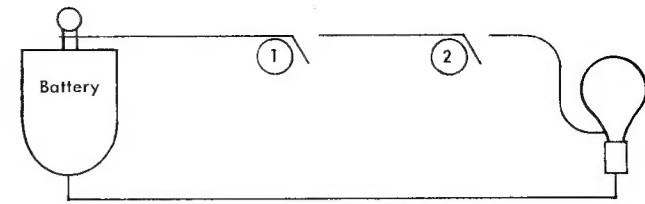
Diagram A
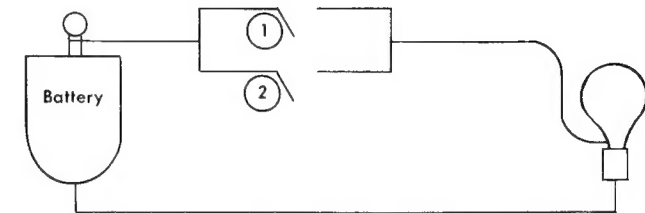
Diagram B
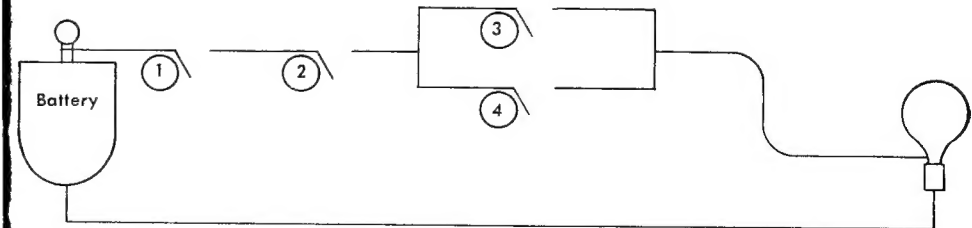
Diagram C

given the proper information, it can find each answer leading to the final solutions of the problem at a fantastic rate of speed.

Storage or Memory

The storage or memory unit is exactly what its name implies: a place where bits of information are placed so that the computer can act upon them according to the programmer's instructions.

In most modern computers, the memory consists of millions of tiny magnets activated by electrical pulses. When the bit of data stored in one of these magnets is needed, a pulse is sent to that particular magnet. All information that goes into the computer's input unit goes first to the memory. It is equivalent to an electronic filing cabinet, completely indexed and instantly available to the computer. (See illustration below.)

Most data-processing computers (those used in handling business accounts, for example) have another storage unit called auxiliary storage. It is outside the main computer unit, and information needed from auxiliary storage must be read into the primary (main) storage unit to be used. However, it is linked directly with the main unit, so that data needed from auxiliary storage unit can be selected quickly by the main computer unit and used.

There are several types of memory or storage units. In the next requirement we will find out how they work.

Output

Just as the human programmer needs a link with the machine to feed data into it, so must he have a link to take answers out. This link is called the output unit.

After all the components from input to control to processing to memory have done their work, the result must be translated back into language that we can understand and answers we need.

Some computers spew out rolls of tape with the answers to the questions we have given them. Others page print their answers, some of them going so fast that they could print this page in less than a second. Still others are even faster, photo printing answers without using any moving parts at the rate of 100,000 words a minute.

And there are some computers that actually give their answers by the spoken word, using previously recorded human voices.

A magnetic core network

A keypunch operator at work on data.

Perhaps the most common output devices are those in data-processing computers that can print such things as payroll checks at the rate of 10,000 an hour. At our Boy Scout national office in New Brunswick, such a computer addresses *Boys' Life* mailing labels at the amazing speed of 45,000 an hour. (See page 41.)

Computer output takes many forms.
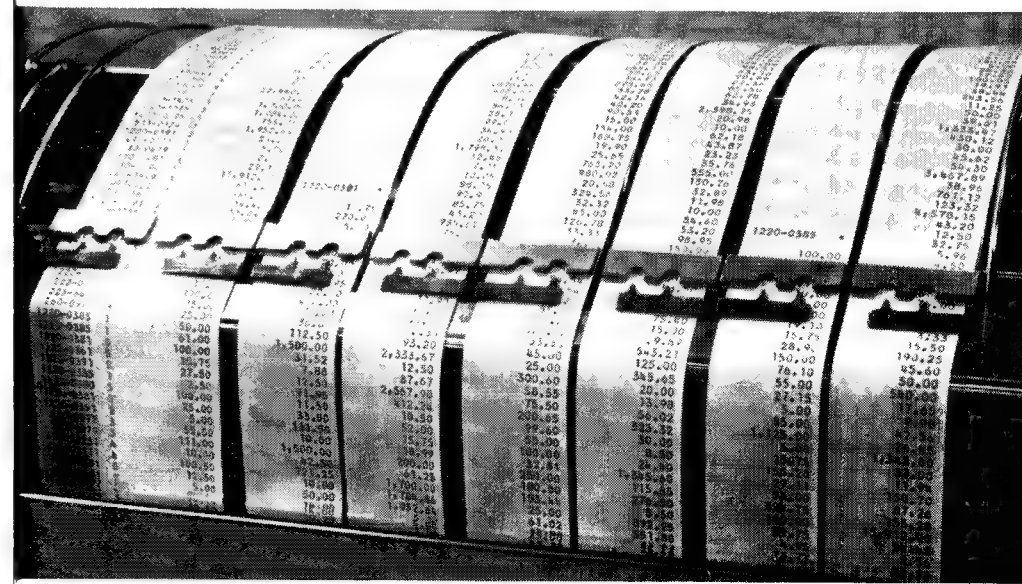
How Computers Remember

3. Build a simple model of one of the following that will help you to illustrate and explain its function in detail: (a) core storage; (b) drum storage; (c) disk storage.

If you have ever worked an office adding machine, you know that you can give it a long series of numbers and it will "remember" them until you strike the "clear" button. The numbers may be printed on a paper tape feeding out of the machine, but when the "clear" button is hit, its memory is wiped clean.

That adding machine is a computer, but compared to modern digital computers it is a Stone Age contrivance. A modern electronic digital computer can store a *billion* pieces of information for as long as we want it to and can use it.

How does it do it? There are three basic methods in use today: core storage, drum storage, and disk storage.

All three are based on electromagnetism, the laws that govern electricity and magnetics. You know that if you get lost on a hike, you can pull out your Scout compass and find North because the needle will line up in a north-south alignment. This happens because the needle is attracted to the magnetic North Pole.

If it were possible to switch the earth's North and South Poles, the compass needle would reverse itself and point in the opposite direction. Although this can't be done, it is possible to reverse the field of a magnet electrically as shown at left. This property of magnetism is used to give memory to a digital computer.

A magnetic field can be changed electrically.

Core Storage

Magnetic core storage is the most widely used type of memory device because it permits the storing of great amounts of information in a small space and because each bit of information is easy to find.

Magnetic cores are tiny, doughnut-shaped rings of ferrite (iron compound) material, a few hundredths of an inch in diameter. See page 23. They look very much like the small beads you would use for an Indian belt or headband. More than a million cores are used in large computers. They are woven together somewhat

Memory cores are magnetized to store information. Illustration at left shows how electrical impulses affect the core magnets in storage.

as you would weave Indian beads, but two wires run through each core, one vertical and one horizontal. Each core is magnetized in either a clockwise or counterclockwise direction, and the direction of its magnetism represents one bit of information for the computer (either 1 or 0, yes or no, etc.).

When the proper pulse of electrical current is sent on a wire through one of these ferrite cores, the core reverses its magnetic field. (A 1 becomes a 0, a 0 becomes a 1, etc.) The computer can store information in any one of a million cores by dividing the electrical current needed to reverse its magnetic field and sending half of it through the proper vertical wire and half through the horizontal one. For example, suppose we want to store a 1 or 0 in the core at the intersection of vertical wire No. 71 and horizontal wire No. 37. Half the current needed is sent through wire 71, and half through No. 37.

Let's pretend we want to store the binary number 1011 in the core storage. See diagram below. The section is now magnetized so that all cores read 0. A punched card or tape activates the proper electrical pulses, changing three cores to 1's and skipping the 0. This number will remain in storage indefinitely until it is changed or erased.

To "read" the information that has been stored in the core storage, there are "sensor wires" interlacing all the cores. These are able to communicate to the computer the status of each core (whether it is in the 0 state or in the 1 state). The process is more complicated than it sounds, but it is still an instantaneous "reading." The assembly of wires and cores is called a core storage plane.

You can build a simple model of a core storage plane so that you can explain how it works, by stringing beads or washers on wires attached to a wooden frame. Of course, this will be a nonworking model, but it will help you visualize core storage operation.
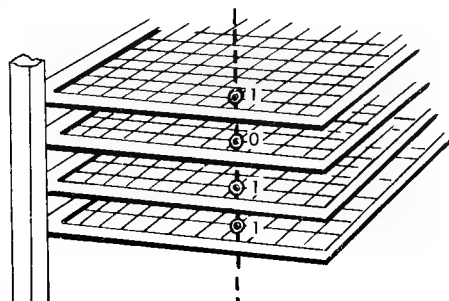
Binary number 1011 in core storage

Drum Storage and Disk Storage

If we put a tiny spot of magnetic material on any surface, it will act like a magnet. If it is placed in a strong magnetic field, it will align itself with that field. If we change the direction of the field by using an electromagnet, the tiny magnetic spot will change its direction, too. The direction of this spot, then, can represent one bit of information for a computer.

But how can the computer tell what that information is? It must have some way to sense this if it is going to have a real memory.

To see how this works, let's move our magnetized spot past the ends of a U-shaped iron core with a wire attached. Since the spot acts like a permanent magnet, it has a small magnetic field of its own. See drawing and explanation below.

Thus, by moving the magnetized spot through the same electromagnet with which we magnetized it, we create a current in the electromagnet. The direction of

How bits of information are organized for storage on a magnetic drum is shown at right. Magnetic "read-write" head, below, stores information on the drum and "reads" it on command of the machine.

25
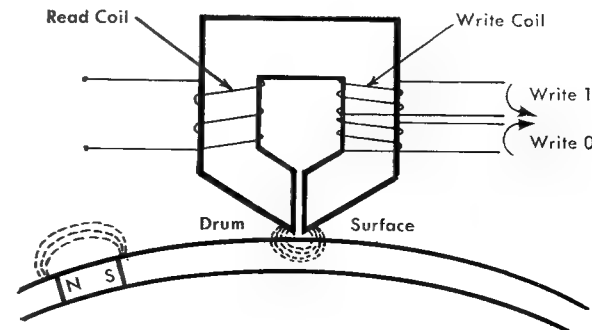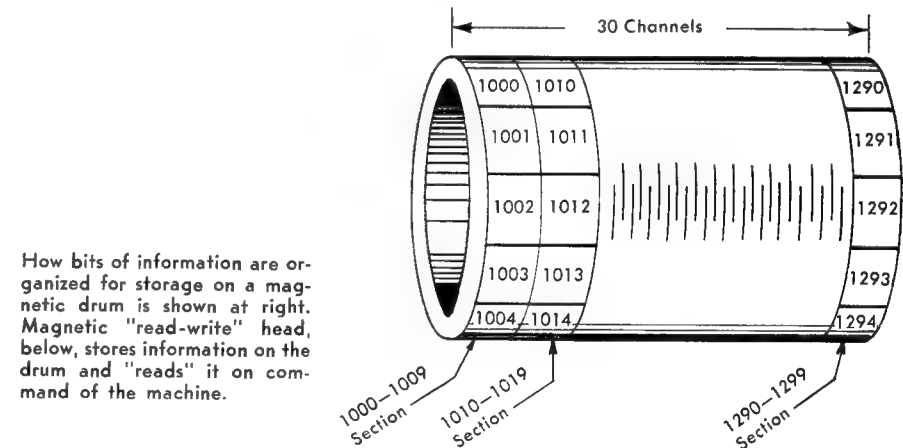
this current depends on the direction in which the magnetic spot was aligned. Therefore, the computer can tell whether the spot represented a "1" or "0."

The computer can read, write, or erase (by writing "0's") one bit of information on each spot of magnetic material. On drum, disk, and tape storage devices, the electromagnet which does the reading, writing, and erasing is called a "read-write" head.

Magnetic Drums

Magnetic drums are rotating metal cylinders marked off in parallel bands or tracks. Each track may be spot-magnetized in either direction by an electrical impulse to represent a bit of data. A read-write head above each track serves as a recorder and sensor. Magnetization in one direction will represent a "1"; while in the other, it means a "0."

Magnetic Disks

Magnetic disks operate on the same principle as drums. They look like phonograph records and rotate in the same way. The disks are made of metal, and their surfaces can be spot-magnetized just like the tracks on the magnetic drum. Several read-write heads may be positioned along the radius of the disk so that data can be read and recorded quickly.

You will have to use your ingenuity to make models to illustrate the working of magnetic drum and magnetic disk storage. Cylindrical oatmeal boxes, phonograph records, and pieces of wood should serve to construct these models so that you can explain how they work to your merit badge counselor.

In disk storage, information is stored on disks and read back as in drum storage.

Read-Write Heads
(1 over, 1 under each disk)

To and From
Internal Storage

Shaft

Tracks on Both Sides of Disk → 1 2 3 4

Magnetic Bits
Representing Characters
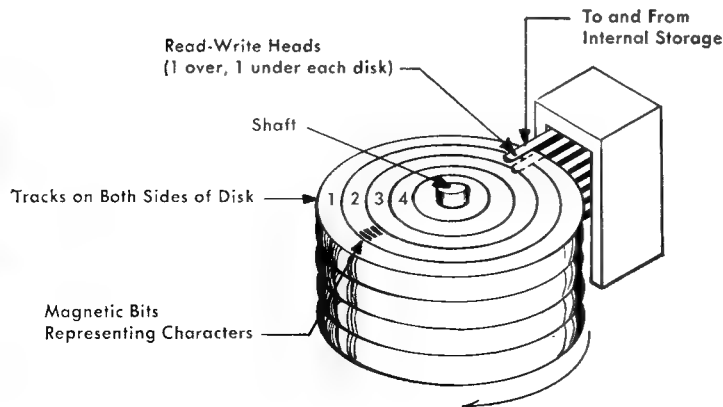
Types of Computers

4a. Describe the differences and uses of analog and digital computers.

The differences between analog and digital computers were mentioned briefly for Requirement 2. There we said: An analog computer measures; a digital computer counts.

This is true enough, but it does not tell us much about the two types of computers. Let's now examine the differences in more detail.

How Computers Differ

We can start finding out how the two types of computers differ by examining the words they come from. The word analog is derived from "analogy," which means to make a comparison betweeen things that are not very similar in themselves. If you say, "A Scout is like a fencepost, straight and strong," you are making an analogy. Very few Scouts look like fenceposts, but the analogy is true; because most Scouts and fenceposts share the attributes of being straight and strong.

The word digital comes from the Latin word digitus, meaning finger or toe. It still means finger or toe to a zoologist. In mathematics it means a figure from 0 to 9.

The words analog and digital suggest the basic difference between the two types of computers: An analog computer compares any two things and gives an approximate measurement; a digital computer counts figures and gives us an exact total.
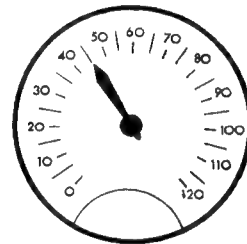
Simple Analogs

One of the most familiar analog devices is the speedometer in your family car. As the car's wheels rotate, a message is sent to a device under the dashboard. This device transforms the message into a reading on a dial. It is an approximation only and its accuracy depends on how good the speedometer is. If the dial reads 50 miles per hour, the car may actually be traveling 48 or 52 mph, but a good speedometer gives your dad a very close approximation of his car's speed.

Another analog calculator you may have seen is the slide rule. It is a ruler with a slide in the middle. Both

Speedometer
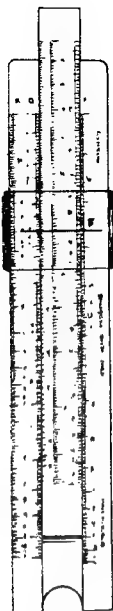
parts are scaled with numbers. Slide rules are used by engineers and scientists in making fast calculations when accuracy to several decimal points is not vital.

The slide rule is multiplying by comparing two lengths, and not dealing directly with numbers as you do when you make the multiplication in your head or on a piece of writing paper.

Simple Digital Computers

The first digital computer, as we saw in Requirement 1, was the abacus. It was followed by Pascal's adding machine and Leibnitz' advanced calculating machine, the ancestors of the electronic digital computers of today.

The fact that identifies all these various computing devices as digital computers is that all of them deal directly with digits or numbers, not with quantities or other measurements.

Modern Analog Computers

Well, you might say digital computers are more accurate than analogs, so why bother with analogs at all? Why not use only digital computers?

The fact is that digital computers *are* gradually supplanting analogs in most fields, but analogs still have their uses because they have certain advantages. For one thing, analogs are usually simpler. Consider the thermometer, which is a simple analog device. A digital computer could be built that would record temperatures, but it would not likely be as simple as a thermometer, shown on page 29.

Another advantage of analogs is speed. We have already talked about the fantastic speed of which digital computers are capable, but for some operations analog computers are even faster. This is because the analog is measuring the operation *as it happens;* there is not even the very brief delay while a digital computer makes its swift calculations.

The analogs that we have mentioned so far have been such simple devices as speedometers, slide rules, and thermometers. But you'll find that there are very complex analogs, too, almost comparable in complexity to their digital cousins.

Many very complicated analog computers were developed before and during World War II which were capable of handling difficult mathematical problems,

ballistics (bullet measuring) equations, and similar engineering questions.

Analog computers were found to be very good at tracking a moving target and predicting its position so that a gun could be aimed correctly to hit it.

After the war, many industrial uses were found for analog computers. They are now used in aircraft design, controlling the flow of electric power, controlling automatic machining processes, and in other applications where simultaneous monitoring of the work is necessary. Analogs are very useful in chemical plants and petroleum refineries where each step of the work is very involved and must be under constant control.

Summing it up, we can say that analog computers have these advantages:

• Simplicity and speed in certain applications

The disadvantages of analogs are:

• They are less accurate than digital computers.

• Most analogs are specialists: They do only one job.

Modern Digital Computers

Basically, the digital computer has no intelligence whatever. About all it really knows how to do is add 1 and 1. All of its mathematical magic is really just repeating that addition of 1 and 1, but it does this at such lightning speed that a digital computer is capable of millions of such additions a second.

Digital computers are adapted to new uses everyday because of these advantages over the analog computer:

• Greater accuracy
• They are usually more flexible than the analog; that is, they can be used for more purposes.
• They are usually more compact than the analog; transistors and other semiconductors can be used in digital computers to greater advantage than in the analogs. Analogs are more apt to have mechanical parts.
• They can handle problems of logic that are beyond the analog.

The digital computer suffers in comparison with the analog only in the fact that for some purposes the analog will give an immediate answer to a problem that might take the digital computer a second or two.

Slide Rule
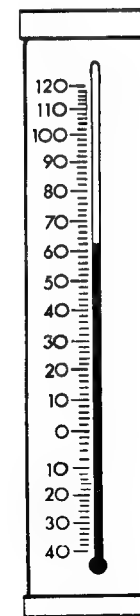
Thermometer

Uses for the Digital Computer

Because of its greater accuracy and flexibility, the digital computer is gradually taking over many functions previously reserved for analogs. Today, hardly a major business or industry is without at least one. For the moment, let's consider how computers are used in other fields.

Internal Revenue Service

In the past few years, the Internal Revenue Service, our country's tax collection agency, has become highly automated. Computer centers have been established in major cities throughout the country.

Tax return information for many years is kept on file by social security numbers of citizens. When a person files a return, a computer checks all entries for completeness, checks the taxpayer's arithmetic, and checks his deductions to make sure they are not higher than they should be.

If errors are found or if a person who has a social security number does not file a return, the computer lets the IRS know about it.

Education

Computers are finding growing acceptance in education. They are used in the classroom primarily as teaching and grading devices.

Teaching machines now offer programmed instruction in which a student need never see a human teacher to complete a course. Both questions and answers are stored in the computer's memory. A question is displayed on a special device, and the student types his answer or makes a choice in a multiple-choice quiz. The computer then analyzes the answer. If it is correct, the machine moves on to the next question. If it is wrong, the machine directs the student to the area where the solution can be found. In this way, a teaching machine can lead a student through a course, taking each area of learning step-by-step.

Simple computers have been used for many years to grade papers for multiple-choice quizzes by checking whether the student chose the correct answers. But now there are computers which can scan and read significant words and characters, thus extending the machine's value as a test grader of accuracy and speed.

Computers don't just help with the educational

Computers are increasingly used in education.

You can learn a lot by visiting a computer installation.

process, though. They are "students" themselves. That is, computers can be taught to learn from mistakes.

Programs have been written for computers to enable them to successfully play ticktacktoe, checkers, blackjack, and even chess.

If a chess-playing computer makes a mistake during a game, it will remember that mistake and never make it again. In this way it can be said to learn. The computer does this by breaking down the problem into its smallest components, just as a human student handles a mathematical formula. Every small problem is solved until the whole problem is finished.

So far, by the way, computers can play only a mediocre game of chess. They are no match for masters.

Law

The number of legal documents in existence today is so immense that no lawyer can possibly hope to examine them all without help to find the ones he needs. And so the laws and court decisions have been classified by the computer. A lawyer simply inquires of the computer by giving it key words or phrases, and the computer immediately gives him a list of cases and decisions bearing on the question he is concerned with.

Medicine

Digital computers serve much the same purpose in medicine. They are used in diagnosis and in compiling information on death rates, which may lead to new breakthroughs in medicine. Doctors may soon have a way to check their diagnoses against a catalog of more than 10,000 diseases.

Other computers, mostly the analog type, are often used to monitor the bodily functions of critically ill persons. Measuring devices are attached to the patient and connected directly to a computer that can keep a constant check of pulse, heartbeat, brain waves, etc. The slightest change in the patient's condition is recorded immediately, often before there is any visual sign of change.

Transportation

Computers are being used to figure the best load for a truck, train, ship, or aircraft. They help management determine the best route to take and even advise the managers what number of vehicles they need to make

Computers are used in many phases of medicine.

Computers are used to find fingerprints quickly.

the most profit. Superspeed trains being developed today must be controlled by computers.

Traffic Control

Most large airports have computers to help control aircraft in the area. Computers can quickly figure waiting time for landing or taking off, aircraft arrival times, etc. For automobile traffic, computers are used to control the traffic lights in cities. They can be programmed to change the timing of the traffic lights according to the volume or direction of traffic or according to a predetermined interval.

Space

There could be no man-in-space program without computers. At every step in preparation for a space shot, and during the countdown and the flight itself, computers are busily making the instant calculations that are necessary.

Thousands of mathematicians, working at top speed, could not make the computations needed for space flight in the fractions of seconds. Computers can and do make them quickly and correctly.

Weather Forecasting

The U.S. Weather Bureau and the Air Weather Service make use of computers in forecasting. Meteorological observations are taken hourly at stations all over the country. To keep forecasts up to the minute, the Weather Bureau relies upon computers for analyzing the great number of factors that must be considered in hourly forecasts.

We have covered only a small sample of the many chores the digital computer performs outside the business field. Its great value is that it does in seconds calculations that might take months by paper and pencil; it also relieves men from dreary tasks so that they can concentrate on the creative thinking that is beyond the capacity of even the most advanced computers at least so far.

There is a debate in the scientific world as to whether computers will ever be able to match or surpass man's brain in subtlety of thought and creativity. Some forgotten wit has pointed out that if that day ever comes we can always pull out the wall plug.

Computerized information helps to route railroad cars.

Space rockets are tracked and controlled by computer.

Feeding a Computer

4b. Explain the Hollerith and Powers codes and their role in computers.

Dr. Herman Hollerith, the statistician, developed the punched card and card machine that was first used in the census of 1890.

This type of punched card is still the most versatile method of feeding a computer because it can contain many varieties of data. For this reason, the punched card is used almost universally by governmental units, utilities, and large-volume stores that must send great numbers of bills to consumers regularly.

No doubt you have seen these $7\frac{3}{8}$- by $3\frac{1}{4}$-inch cards when your dad was paying bills or perhaps when he brought home his paycheck. The clipped corner, a distinguishing feature on many cards, serves a valuable purpose; it gives the machine operator visual assurance that all cards in a series are facing in the same direction as they are fed into the machine. If they were not, your dad might get a gas bill for $3 million when it should be $30.

Data are recorded on punched cards by means of holes punched in appropriate positions in horizontal or vertical columns. The Hollerith or IBM card contains 12 horizontal rows and 80 vertical columns for punches.

The lower 10 rows are used to represent the 10 digits 0 through 9. The top three rows are called zone rows and are used with rows 1 through 9 to represent alphabetic codes. Each letter is represented by a distinct combination of one zone punch and one digit punch. Note that in coding alphabetic characters, rows 1 through 9 carry part of the coded information while the three zones carry the remainder. Special characters are represented by other combinations of punches not used for numbers or letters. Most machines that use this coding system will accept 48 different characters --some will accept 64. With 12 possible punching positions, there is a theoretical maximum of 4096 possible coded characters.

Users often have their cards specially printed to identify certain fields, or groups of columns that are to contain certain types of information (the customer's name, a part number, etc.). This serves as a guide to the keypunch operator, the machine operator, and others who must refer to the cards. We will learn more about the Hollerith code in Requirement 8.

Although the 80-column Hollerith card is the most
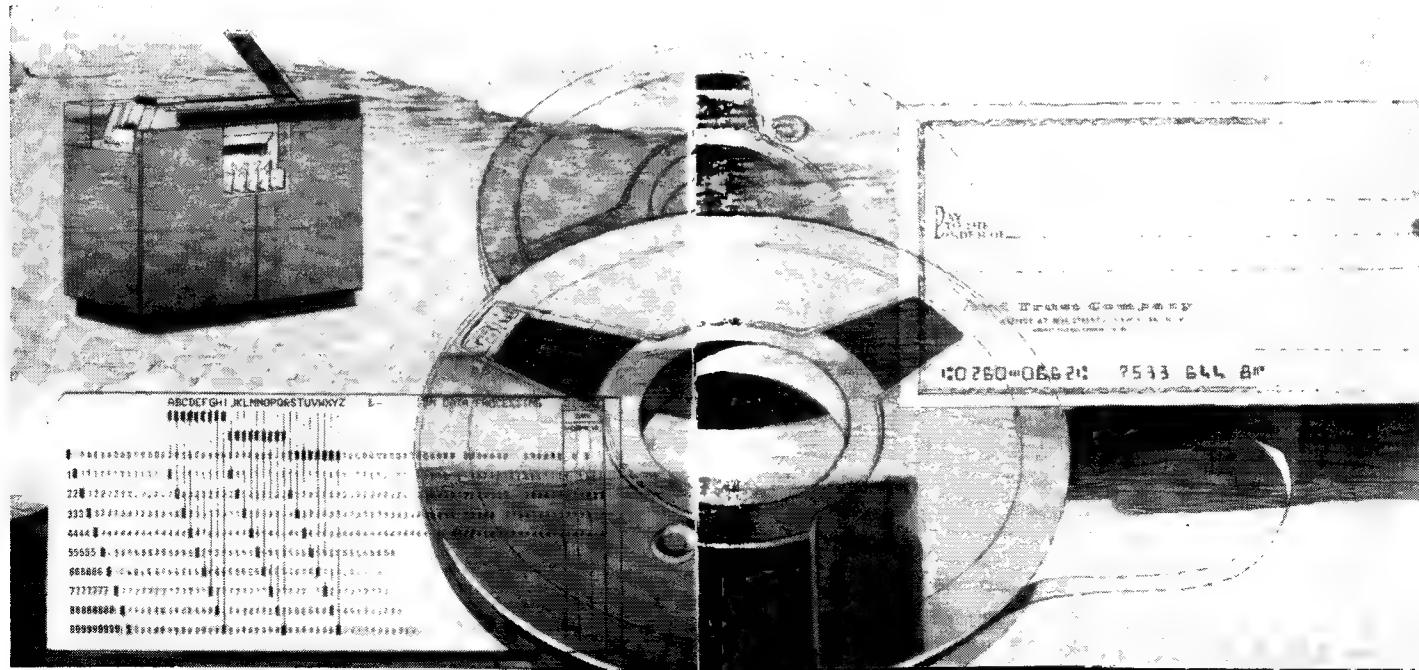
common, another type is in general use. This is called the Powers or Remington Rand card. It has 90 columns and is divided into upper and lower halves of 45 columns each. On this card, odd numbers and zero are represented by a single punched hole. Even numbers are represented by two holes. Alphabetic characters are coded with combinations of two or three holes.

The holes in the Powers card are round, whereas those in the Hollerith card are rectangular.

How the Cards Are Used

The punched cards by themselves are of little value; they must be read by the electronic data-processing machine to do their work.

The hole in a punched card can be read and interpreted mechanically, electrically, or optically. The most common method is an electrical one in which the card enters the computer's reading device and passes between a metal drum and a series of metal reading brushes. If there is a hole in the card, the brush makes contact with the metal drum; no punch, no contact.

Read Hopper   First Read

Second Read

Stacker Drum

Stacker
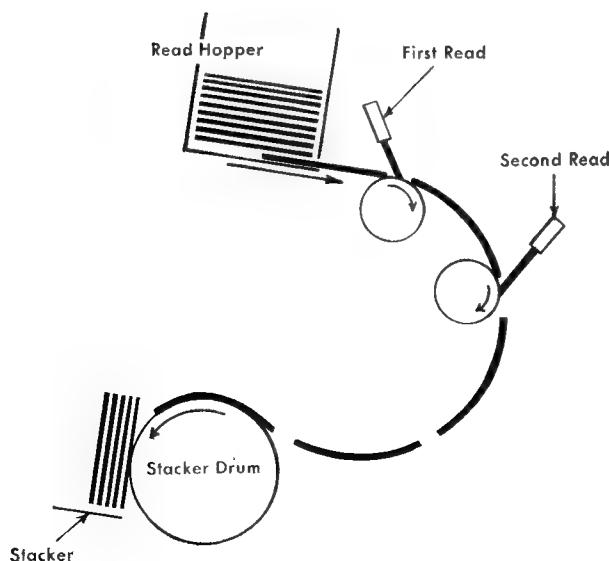
This simplified drawing shows how the brush makes contact with the drum through the punched holes of its particular column on the key-punch card. This contact sends an electrical impulse to the computer's processing unit, instructing the computer exactly what to do.

Speeding the Mails

5. Obtain your local post office ZIP code and convert to binary.

Billions of pieces of mail flow through post offices all across America each year, and the Post Office Department is constantly automating its handling of the mail to keep up with the flood.

One of the ways the Post Office Department is attacking the problem of volume is by asking that all mail carry a special code at the end of the address. Each section of a city and each small town and rural area has its own special number called its ZIP code that aids the computer in directing mail without delay. The computer scans the number and sends it quickly on its way without having to look up the location of, say, West Centerville, Iowa.

Each ZIP code number has five digits. The first digit identifies one of 10 very large geographical areas of the United States. Together, the first three digits identify a city or major distribution point called a sectional center. The last two digits narrow down the computer's search for the destination to an area within a city or a specific delivery unit.

Converting to Binary

For Requirement 2, it was explained why binary is used in computers. You will recall it uses only the digits 1 and 0 because of the nature of digital computers. On page 16, there is a table comparing binary with the numbers from 0 to 9 in the decimal system that you use every day in school.

Now suppose you live in Emporia, Kans. Kansas is part of ZIP code region 6, which also includes Nebraska, Missouri, and Illinois. So we know the first digit in its ZIP number will be 6. The next two digits identify Emporia as a city in eastern Kansas, not far from Topeka. The final two digits narrow down the search to the city of Emporia.

Emporia's ZIP code number is 66801. The table on page 16 only goes as high as the decimal 9, so we must learn a little more about binary before we can convert a large number like 66801.

There are several ways to make the conversion. Perhaps the simplest is by dividing the number by 2 again and again until 0 is reached, without using any fractions. Instead of using fractions, we record the "leftovers" when we have an odd number to divide. Now let's see how this works by finding the binary for the decimal number 6:

Half of 6	3	Leftover 0
Half of 3	1	Leftover 1
Half of 1	0	Leftover 1

Now if we place these leftovers in a row, starting from the bottom, we have our binary for 6, which is the number 110.

Now let's apply this process to our ZIP code number for Emporia 66801.

Half of 66801	33400	Leftover 1
Half of 33400	16700	Leftover 0
Half of 16700	8350	Leftover 0
Half of 8350	4175	Leftover 0
Half of 4175	2087	Leftover 1
Half of 2087	1043	Leftover 1
Half of 1043	521	Leftover 1
Half of 521	260	Leftover 1
Half of 260	130	Leftover 0
Half of 130	65	Leftover 0
Half of 65	32	Leftover 1
Half of 32	16	Leftover 0
Half of 16	8	Leftover 0
Half of 8	4	Leftover 0
Half of 4	2	Leftover 0
Half of 2	1	Leftover 0
Half of 1	0	Leftover 1

Putting these leftovers in a row, starting from the bottom, we have 100000010011110001, which is Emporia's ZIP code in binary.

If we want to change binary back to decimal, we place a 1 beside the binary's *last* digit, a 2 beside the next, etc., multiplying by 2 each time. Then we cross out all the decimal numbers that are next to a binary 0 and add the remaining numbers.

1	1
0	2
0	4
0	8
1	16
1	32
1	64
1	128
0	256
0	512
1	1024
0	2048
0	4096
0	8192
0	16384
0	32768
1	65536

Since binaries are made from decimal numbers by using the powers of 2, we have merely used these powers in reverse to convert Emporia's number in binary back into the decimal form.

This machine can address 45,000 Boys' Life magazine mailing labels in about an hour from stored computer data.

Setting Up a Problem for the Computer

6. Using the flowchart diagram method, show the steps necessary to set up a campsite.

The electronic digital computer cannot do anything you could not do with a paper and pencil given sufficient time, but it can add hundreds of figures or multiply a couple of eight-digit numbers in the time it would take you to draw the line under the problem.

However, it must be told what to do, step by step. Great care must be taken to tell it exactly what is to be done and in what order, or the result will be a gigantic error worthy only of a magnificent idiot. Data-processing machine workers have a graphic expression for this need for accuracy: "Garbage in, garbage out." This expression, of course, could be applied to a lot of things we do, and even what we think.

To make sure that he will feed the computer the proper instructions, the programmer makes a diagram called a flowchart before he actually begins writing the program that will be put into the machine. The flowchart breaks the problem down into steps that you might do in your head without thinking about it if you were solving the problem yourself.

Making the flowchart often takes much longer than the computer does to solve the problem when it finally gets it. A flowchart for the calculations needed to fire a space vehicle, for example, may take hours; the calculations themselves may be completed by the computer within minutes or seconds.

Let's make a simple flowchart now to see how it is done. Suppose we want to find the average of three numbers – 5, 6, and 7. Probably you already see the answer, or maybe you are now busy adding the numbers and dividing by 3.

But the computer is a moron or worse. It must be told everything, and so we make a flowchart of the problem that resembles the illustration on page 43.

For this requirement, you must show the steps necessary to set up a campsite by making a flowchart of them. This, of course, is not a mathematical problem. Rather, it is a problem of logic.
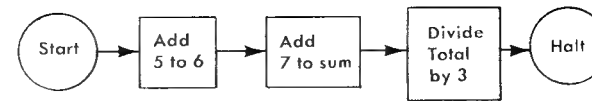
A simple flowchart

And so your flowchart will have directions, questions, and answers rather than digits. The chart on pages 44 and 45 gives you an idea how to go about making it. In this chart, the rectangles give directions; the diamonds ask questions.

Since you have probably been camping many times as a Scout, you know the logical steps for setting up a campsite. Keep in mind that although many steps may seem self-evident to you, they would not be to a computer, so you must consider every move and every question that goes into establishing a camp.

Here are a few of the things that ought to be included:

- Step 1—Choose site for patrol cooking fly. Whole patrol unpack cooking fly. Whole patrol helps set it up.
- Step 2—Place packs under fly. Divide food and patrol equipment into separate piles.
- Step 3—Divide patrol into buddies.
- Step 4—Dig latrine if needed.
- Step 5—Buddies make fire area, gather firewood, get water, and make fire. What tools are needed?
- Step 6—Cooks prepare meal.
- Step 7—Meal cleanup detail goes to work.
- Step 8—Buddies pitch own tents.

If you need help to make sure you are not forgetting anything, review the material on setting up a camp in the *Camping* merit badge pamphlet.

Left flowchart (page 44)

```
GET COMPUTERS MERIT BADGE PAMPHLET
                    |
                    v
DEAD  <--YES-- TOO  <----- READ
END            HARD        REQUIREMENTS
                |NO
                v
TALK TO --------> READ BOOK <------
COUNSELOR         AGAIN           |
                    |             |
                    v             |
              UNDERSTOOD --NO-----
                    |YES
                    v
              STUDY AND DO
              REQUIREMENTS
              1 AND 2
                    |
                    v
              STUDY AND DO
              REQUIREMENT 3
              CHOOSE ONE
              |      |      |
              v      v      v
            3-A    3-B    3-C
              |      |      |
              v      v      v
              STUDY AND DO
              REQUIREMENT
              4
                    |
                    v
ASK MOM OR  <--NO-- KNOW
DAD FOR ZIP CODE    ZIP CODE
        |             |YES
        |             v
        ----------> STUDY AND DO
                    REQUIREMENT "5"
                        |
                        v
                    STUDY AND DO          GO TO
                    REQUIREMENTS  ----> REQUIREMENT
                    "6, 7, 8, 9"           10
```

44

Right side (page 45)

Making a flowchart for a computer

```
              STUDY AND DO
              REQUIREMENT 10
              CHOOSE TWO
          |      |      |      |
          v      v      v      v
        10 A   10 B   10 C   10 D
          |      |      |      |
          v      v      v      v
              STUDY AND DO
              REQUIREMENT 11
                    |
                    v           <------
              READY --NO--> REVIEW BOOK
              TO            AGAIN
              PASS
                    |YES
                    v
              VISIT
              COUNSELOR
```

45
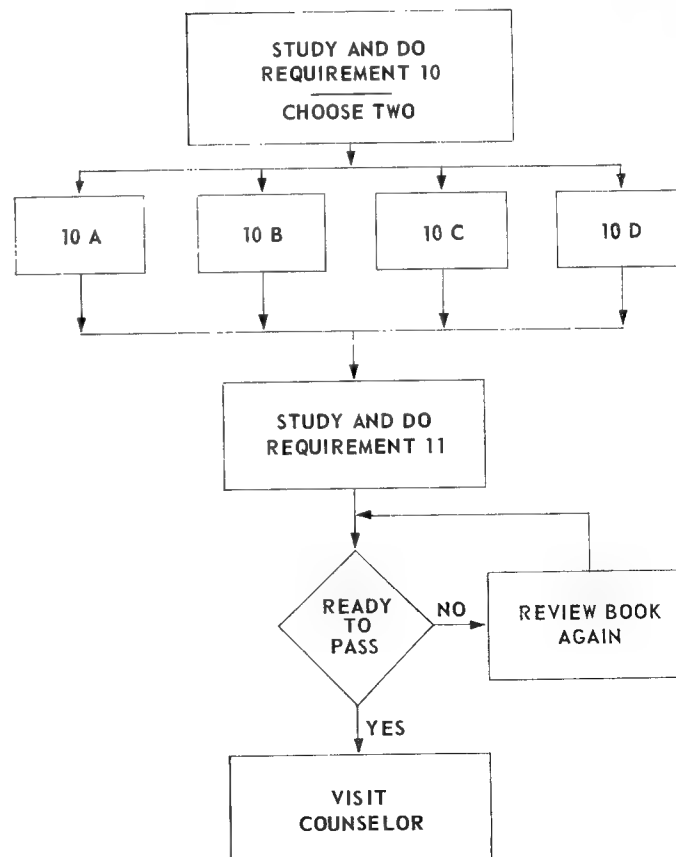
Computers at Work

7. Name four different uses of computers.

New uses of the computer are being found every day, especially in the business or industrial world.

The computer is ideally suited to be the businessman's friend, because businessmen are called upon daily for hundreds, thousands, or even millions of calculations and decisions. Most of the calculations are relatively simple, but the sheer volume of them would overwhelm large companies or industries without the computer's help.

The digital computers used in business are usually referred to as electronic data-processing systems (EDP). They are basically no different from the computers used in scientific, industrial, and engineering work, and, in fact, many could easily be used on both types of problems.

These computers, however, are usually called upon to do thousands of simple computations while the machines used in science, industry, and engineering are more likely to be used for fewer but more difficult calculations.

Perhaps the two businesses which make the greatest use of data-processing equipment today are banking and insurance. Both require just what EDP can supply: speedy computations and high volume. But supermarket chains, the stockmarket, hotels, the auto-parking business, publishing, radio and television, all make good use of computers. And, of course, nearly every sizable business of any sort now uses computers to handle its payroll and other business accounts.

How Computers Are Used

There are six areas of almost any business or industrial operation where computers can be used to advantage. Let's look at them one at a time.

Payroll • This is one of the most common applications because such items as wages, withholding tax, etc., are common to every employee. In most data-processing systems, the data (hours worked, pay rate, etc.) are punched into cards and read by the computer.

The computer then multiplies the hours worked by
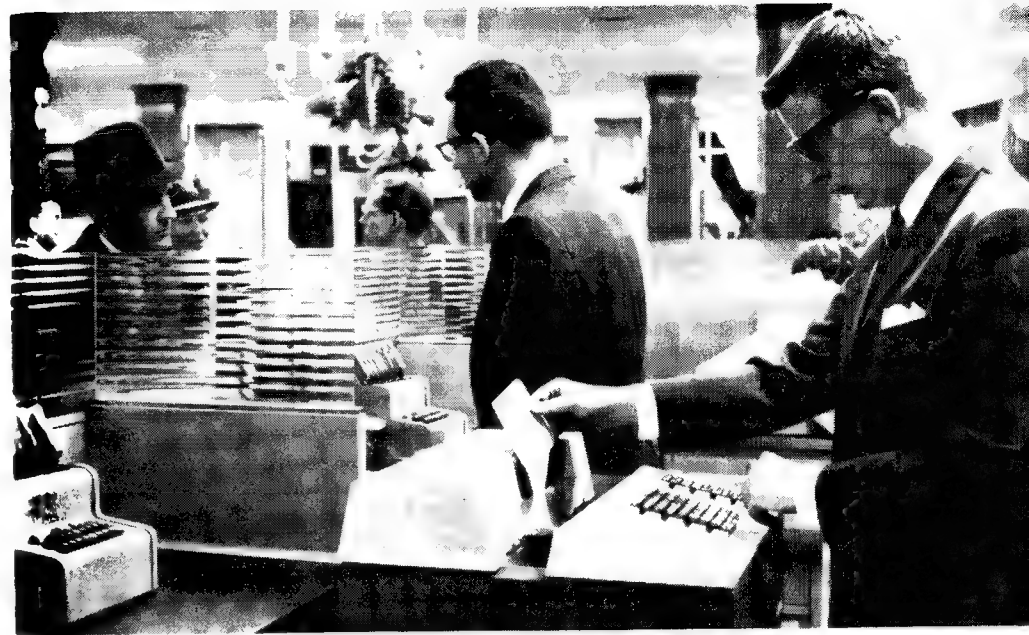
Many different businesses and industries use data processing.

ACCUMULATIVE EARNINGS PAYROLL REGISTER			HADUN MFG. CO.			
EMPLOYEE NO.		EMPLOYEE NAME	SOCIAL SECURITY NO.	FICA	WITH HOLDING TAX	GROSS EARNINGS
DEPT.	SERIAL					
1	206	ASTOR WV	068-32-1451	108.80	386.60	$3,960.90
1	342	ATCHISON FA	021-01-1234	123.45	426.63	$4,115.43
1	518	BAKER HE	781-26-9870	34.30	210.60	$1,810.45
1	615	BILLINGS LF	035-01-4897	144.00	777.20	$7,921.20
1	703	BRACKETT EJ	432-67-5931	62.88	7.80	$2,096.06
1	893	CASPER AF	210-34-6458	96.73	296.40	$3,224.17

Position 11 - 13   16 - 20   24 - 37   40, 41   44 - 54   58 - 63   69 - 74   79 - 87

the base pay, totals the deductions, and subtracts that from the gross pay to arrive at the total the employee should receive. Finally, the computer takes the information and prints the worker's check.

Computerized Accounting • More and more companies are using computer systems for billing, updating accounts, computing discounts, and balancing accounts. Computers can handle this very detailed work much faster and more accurately than bookkeepers.

Marketing • The application of computers to marketing problems is constantly increasing. The great advantage of the computer in marketing is that it can quickly analyze the company's past sales record in light of any factor management wants to know about. As a result, the computer can recommend (based purely on statistical analysis) what products will sell best at what price.

A manufacturer of baseball bats, for example, might want to know in December how many bats he ought to have in stock on April 1. He might tell the computer how many bats he has sold in each of the past 3 or 4 years and what the census bureau reports about the increase in the number of boys of baseball-playing age. With these and other factors, the computer could estimate how many bats will be sold this year.

Inventory • An inventory is an itemized list of goods and their value. In businesses that have very large inventories and high volume, the computer is invaluable because it can keep the management aware of and up-to-the-minute on its stock.

Now, business can keep reduced quantities of goods on hand because management does not have to stock large quantities for fear that it will run out of an item.

Cost Control • Cost control is a system of integrating every financial aspect of a business so that management always knows its financial picture. Computers are now aiding management to a degree not possible with human accountants.

Computers are used to compute budgets years in advance. They can keep up to date with current expenditure as related to planned expenditures and point out to management where the budget is being exceeded. This allows management to know exactly how much money is being spent and where.

Using computers for airline reservations

Credit System • The use of credit in daily purchases has increased substantially in recent years. A typical example is the gasoline credit card. If your dad uses one, when he buys gas or oil his credit card number and the amount of the sale are recorded on a sales slip.

At the data-processing office, this data is either punched on cards and read into the computer, or the sales slip itself may be optically scanned by the computer and the data read directly into the computer's memory. His account is updated, and at the end of the month the computer prepares a bill for what he owes.

Computerized credit cards speed billing.
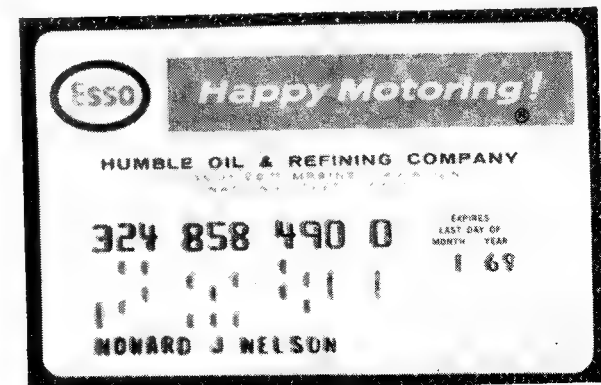
Talking "Machine Talk"

8. Convert your full name to each of the following codes: (a) Hollerith; (b) binary-coded decimal; (c) eight-channel standard code.

When discussing the postal ZIP code, we explained binary—the arithmetic based on just two digits, 0 and 1. Binary is used in many computers that deal only with numbers.

But what about data-processing machines that are called upon to work with letters instead of numbers? Like the ones that print your address label for your *Boys' Life* magazine?

To make this possible, the machine has to be fed a code in which combinations of numbers are used to represent letters. Three of the most popular codes are the Hollerith, binary-coded decimal, and eight-channel standard code.
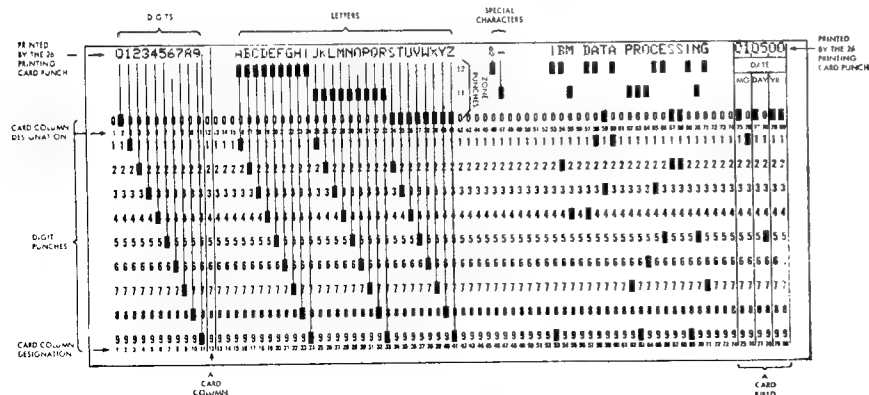
Hollerith Code

Herman Hollerith, you will remember, developed the first data-processing machine that was used on a major scale to handle the data from the 1890 census. His punched-card system is still in use today, and the code for his cards is known as Hollerith or standard IBM code.

Look at the card below. It has been marked with special lines to show how the keypunch operator can indicate numbers or letters, using the Hollerith code.

There are 80 up-and-down columns, containing 10 numbers from 0 through 9, inclusive. At the top of the card, in the middle, you will see numbers 11 and 12, which are called zone punches.

Now, if you will look along the top edge of the card, you will see how the card punch operator can record numbers by punching the actual numbers (digits). Then by punching a zone punch above (12 for A to I, 11 for J to R, and 0 for S to Z) and a number below, he can record any letter of the alphabet.

Written down as a code, it looks like this:

HOLLERITH CODE

						Numbers	
A	12-1	J	11-1	S	0-2	0	0
B	12-2	K	11-2	T	0-3	1	1
C	12-3	L	11-3	U	0-4	2	2
D	12-4	M	11-4	V	0-5	3	3
E	12-5	N	11-5	W	0-6	4	4
F	12-6	O	11-6	X	0-7	5	5
G	12-7	P	11-7	Y	0-8	6	6
H	12-8	Q	11-8	Z	0-9	7	7
I	12-9	R	11-9			8	8
						9	9

Here's another card, an actual one that was used to record a lot of information about a *Scouting Magazine* subscriber. Take a ruler and place it vertically along the first column under "NAME" and follow along until you have the man's name and address. We'll give you a tip—the first two columns say "Mr." See if you can read any of the other information on this card, which can be fed into a card reader and a printer to make labels, bills, lists of subscribers, etc.

How punch card records information

See if you can read this *Scouting Magazine* subscription card.
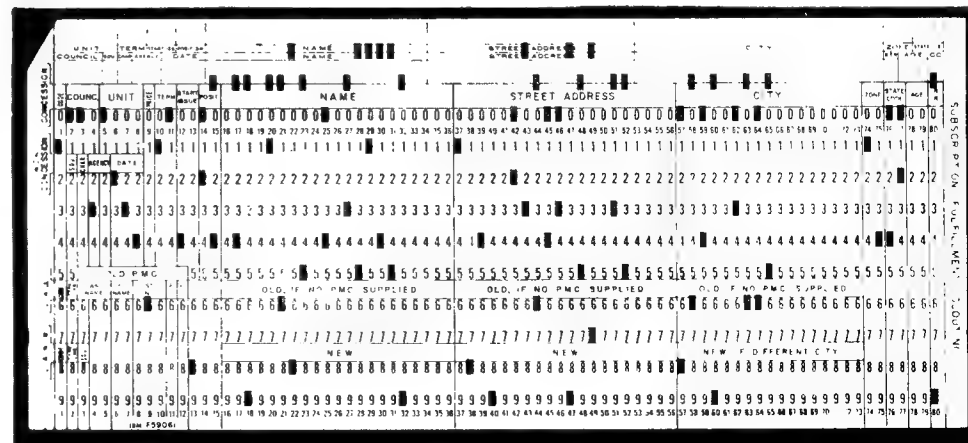
Now you're ready to put your own name into Hollerith code for this requirement. If your name were Samuel John Goodscout, it would look like this:

0-2	12-1	,11-4	0-4	12-5	11-3	11-1
11-6	12-8	11-5	12-7	11-6	11-6	12-4
0-2	12-3	11-6	0-4	0-3		

Binary-Coded Decimal

Another computer coding system is called the binary-coded decimal system. This system uses different combinations of binary numbers to indicate different numbers and letters. For example, to indicate the numbers 1-9, the regular binary numbers are used, but zeros are added in front of them to make them all the same number of digits.

For example, here are the decimal numbers from 0 to 9 and the binary-coded decimal numbers that match them.

Decimal	BCD Equivalent
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001

In the same way, binary numbers can be used to indicate the letters of the alphabet. To indicate the A to I group, a 0 and 1 are tacked onto the front of the first 10 coded binary numbers. The J to R group has a 1 and a 0 tacked onto the front of the first 10 coded binary numbers and from S to J two 1's are added in the same way. For example, here is the binary-coded decimal way of spelling the alphabet.

Alphabetic Letters

A	010001	F	010110	K	100010	P	100111	U	110100
B	010010	G	010111	L	100011	Q	101000	V	110101
C	010011	H	011000	M	100100	R	101001	W	110110
D	010100	I	011001	N	100101	S	110010	X	110111
E	010101	J	100001	O	100110	T	110011	Y	111000
								Z	111001

So, if your name were Samuel John Goodscout, it would be a real mouthful in binary-decimal code. Take a look at the top of page 53.

110010	010001	100100	110100	010101	100011
100001	100110	011000	100101		
010111	100110	100110	010100	110010	
010011	100110	110100	110011		

Eight-Channel Standard Code

We have seen that there are several methods of feeding information into a computer. Another way is by means of a continuous paper tape with punched holes in it. These holes are punched to indicate letters, numbers, and other information according to the eight-channel standard code. The tape looks like the picture below:
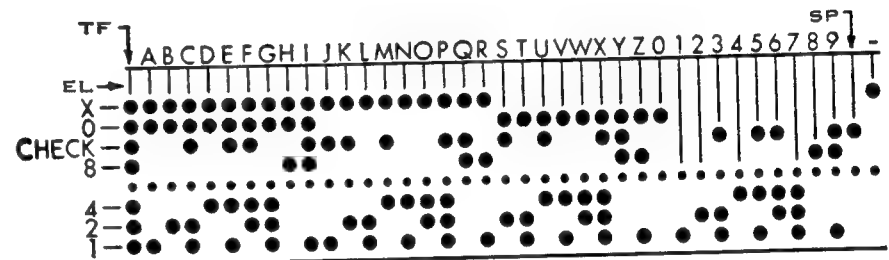
You can see that there are eight columns in which to punch the code. We will just use six of them since they are all you will need to write your name for the requirement.

We have printed the code, alphabet, numbers, etc., for your information. These do not appear on tape, as it is used in computers.

First, look at the numbers. The values of the punched holes are added together to give the numbers. The alphabet would be as follows:

A - 10X	F - 240X	K - 2X	P - 124X	U - 40
B - 20X	G - 1240X	L - 12X	Q - 8X	V - 140
C - 120X	H - 80X	M - 4X	R - 18X	W - 240
D - 40X	I - 180X	N - 14X	S - 20	X - 1240
E - 140X	J - 1X	O - 24X	T - 120	Y - 80
				Z - 180

So, if your name were Samuel John Goodscout, coded in the eight-channel standard code it would look like the following:

20, 10X, 4X, 40, 140X, 12X
1X, 24X, 80X, 14X
1240X, 24X, 24X, 40X, 20, 120X, 24X, 40, 120

Computer Terms

9. Be able to tell your merit badge counselor in your own words the meaning of the following words or terms:

Functional units	Information retrieval
Storage	Solid-state components
Input and output devices	Nanosecond
Random access	Stored program
On-line system	Console
Central processing unit	Optical reader
Magnetic ink characters	Register

Electronic computers are still in their infancy. It is not much more than 20 years since the ENIAC went into service. But in that short span—short as man measures time—a special language has grown up to express the computer's special qualities.

We have already dealt with such words as bit, binary, flowchart, and zone, all of which have special meanings for computer personnel.

In this requirement, you are asked to learn a few of the many other terms with special meanings in a computer worker's vocabulary.

Functional Units.—The four major components of data-processing machines: input devices, output devices, storage, and central processing unit (arithmetic-logic unit and control unit).

Storage.—A general term for any device capable of retaining information.

Input and Output Devices.—Machines for feeding data into and taking data out of the computer.

Random Access.—Ability to find a bit of information immediately without searching through all the data in sequence. Paper and magnetic tape storage do not have this quality; the machine must run the tape through until it finds the proper bit of data. Magnetic core storage, and, to a lesser extent, magnetic disk storage, do have random access; they can find the desired bit without searching through all the information in the order it was stored.

On-Line System.—Operations using the whole computer. Special data conversion operations, such as transcribing information automatically from punched cards to magnetic tape, may take place off-line, using input-output devices independently.

Central Processing Unit.—The part of a computing system that includes the arithmetic-logic unit and the control unit.

Magnetic Ink Characters.—Characters printed with ink containing particles of a magnetic substance that can be read by automatic devices; for example, the digits printed on some bank checks.

Information Retrieval.—Recovery of data originally fed in and stored by a computer.

Solid-State Components.—Transistors and other small semiconductor devices that have replaced vacuum tubes in computer systems.

Nanosecond.—One billionth of a second. (A millisecond is one thousandth of a second, and a microsecond is one millionth of a second.)

Stored Program.—Instructions in storage. They might be a single operation or a series of operations that can be put into a new program by the programmer.

Console.—A panel which contains lights, keys, switches, and related circuits for man-machine communication. The operator controls the system and monitors its operation through the console.

Optical Reader.—A recently-invented scanning machine that can read printed or written material and transform it into "machine talk."

Register.—A device capable of receiving information, holding it, and transferring it as directed by control circuits. Registers might be magnetic cores, transistors, or vacuum tubes.

Learning About Computers

10. To complete this requirement, do two of the following: (a), (b), (c), or (d).

a. Arrange with your counselor to visit a local computer installation.

After having gone this far toward earning your Computers merit badge, you will want to see a computer in action. This might be a data-processing unit in a bank, store, or industrial firm's office. Or it might be one of the computers used directly on industrial processes such as those that control the operation of other machines. Or perhaps one of the computers that controls the flow of air traffic at a large airport.

Supplemental Reading

b. Obtain and read two pieces of information about computers other than manufacturer's literature. Summarize what you read for the counselor. (See page 64.)

Careers in the Computer Field

c. Write a 500-word report on the various types of specialist occupations available in the computer field. Include educational requirements and average wage brackets, when possible.

The computer has grown in less than 20 years from a fledgling understood by only a few scientists and engineers to a household word. Keeping pace with the "computer explosion" is the increased need for trained personnel to work with computers in business, industry, government, schools and colleges, the space program, the military services—in fact, in nearly every facet of our national life

No one can predict with certainty how many people will be needed in the computer field, or what their jobs will be by the time you are ready to begin your life's career. All we can say is that the opportunities now are excellent; by the time you are prepared, they will be almost boundless.

Computer personnel fall into four main groups: data-processing managers, systems analysts, computer programmers, and operating personnel. All require at least a high school education, and the standards are constantly rising. Many employers want men with advanced degrees for these positions.

Let's take a look at these jobs:

Data-Processing Managers.—They plan, coordinate, and direct the data-processing work for the organization, supervising computer centers and punched card installations. They must possess high managerial as well as technical skills. They are paid highly, often over $25,000 a year in large companies.

Systems Analysts.—They develop methods for data collection, processing, and reporting. They try to improve efficiency by making the best possible use of equipment. Their salaries range from $10,000 to $20,000, depending on their skill and the organization.

Computer Programmers.—They work closely with systems analysts to define problems, analyze input data and output report requirements, and prepare the program of instructions for the computer. They must have strong logical and creative abilities. Salaries range from about $7,000 to $18,000.

Operating Personnel.—These include console operators, keypunch operators, tabulating operators, data typists, and computer operators. Their wages vary depending upon skills.

If you think you might like a career in the computer field, you can get more information by writing to the Data Processing Management Association, 524 Busse Highway, Park Ridge, Illinois, 60068.

Checking the Output

d. Show your counselor five examples of data-processing output or the tape, cards, or report forms used.

We have seen that the output of a computer used for data processing may be in several forms. The most familiar output is punched cards. But data-processing output might also be punched paper tape, magnetic tape, or printed forms.

To meet this requirement, you will have to borrow some bills from your dad to show your counselor. Or, if you make a trip to see a computer installation, you may be given some tape or printed forms to keep.

Building an Analog Computer

11a. Construct an analog adder and explain its operation.

If you have watched a modern computer at work, it may have seemed complicated beyond belief, and it may never have occurred to you that you can build a computer yourself.

The one shown on page 59 is, of course, very simple in operation, but it is a computer just as much as that big machine you saw in a bank or office. The plans are for a computer called an analog adder.

Analog computers, you will remember, do not count; they measure. This one measures an electrical current. Through its measurements, it does simple addition. Building and using it give a graphic demonstration of how analogs work.

You will need the following parts, which can be obtained at a radio-TV parts store:

3 100-ohm linear taper potentiometers. These are instruments that vary resistance of electrical circuits.

3 knobs (for potentiometers), 1 9-volt transistor radio battery, and 1 mounting board or box.

On the circut diagram for the computer the two "input" potentiometers, R-1 and R-2, are shown mounted on a board with connections. The meter (1 500-milliampere DC ammeter to measure current) may be either a single range low voltage voltmeter or the low voltage range on a volt-ohm meter.
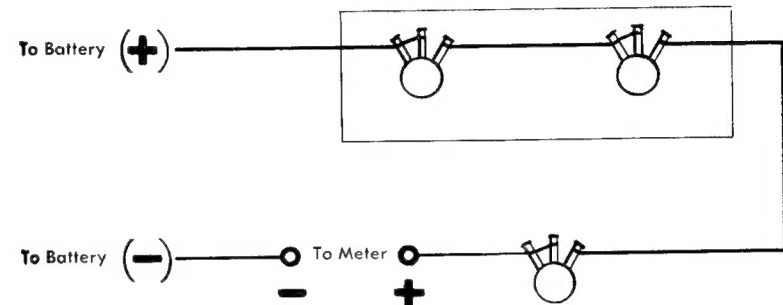
Adjustment

The principle of this simple analog circuit is that the voltmeter will register the sum of the dial settings of the two input potentiometers. For example, if you set both dials at "2," the voltmeter should register "4."

In order to adjust (calibrate) this computer correctly, turn both R-1 and R-2 dials to the "5" position. Then adjust the third potentiometer (R-3) until the voltmeter reads "10." Now you can add with your computer by setting the dials as you wish and reading the meter for your answer. A "4" and a "1" setting on the R-1 and R-2 potentiometers will give a "5" reading on the voltmeter, and so on.
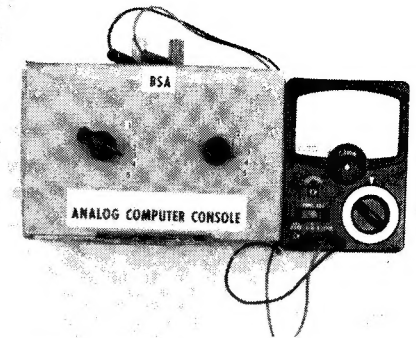
Ask your counselor about borrowing a voltmeter to demonstrate your analog computer.

To Battery (+)

To Battery (—)   To Meter

Back View of Wiring

9v

100 ohms.   R1

100 ohms.   R2

R3

100 ohms

A
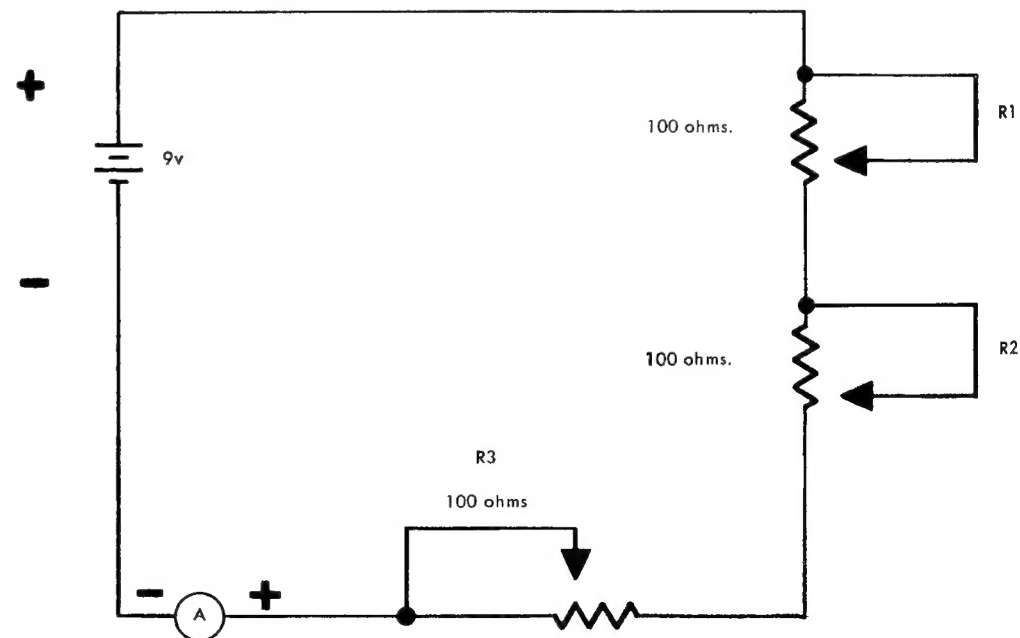
Building a Card-Reading Machine

11b. Construct a card reader, demonstrate it to your merit badge counselor, and explain to him the difference between the Hollerith card code and the internal machine code.

The BSA card reader will show you the principles of an electromechanical card reader. A real one would be considerably more complicated, of course, but building the BSA reader will give you a good idea as to how card reading is done.

The card reader senses holes punched in a card by making an electrical contact through the holes. The conversion from the card code to the internal machine code is accomplished by proper arrangement of the contacts in the reader portion. When you use your card reader, light bulbs will light depending on what holes you have punched in the card.

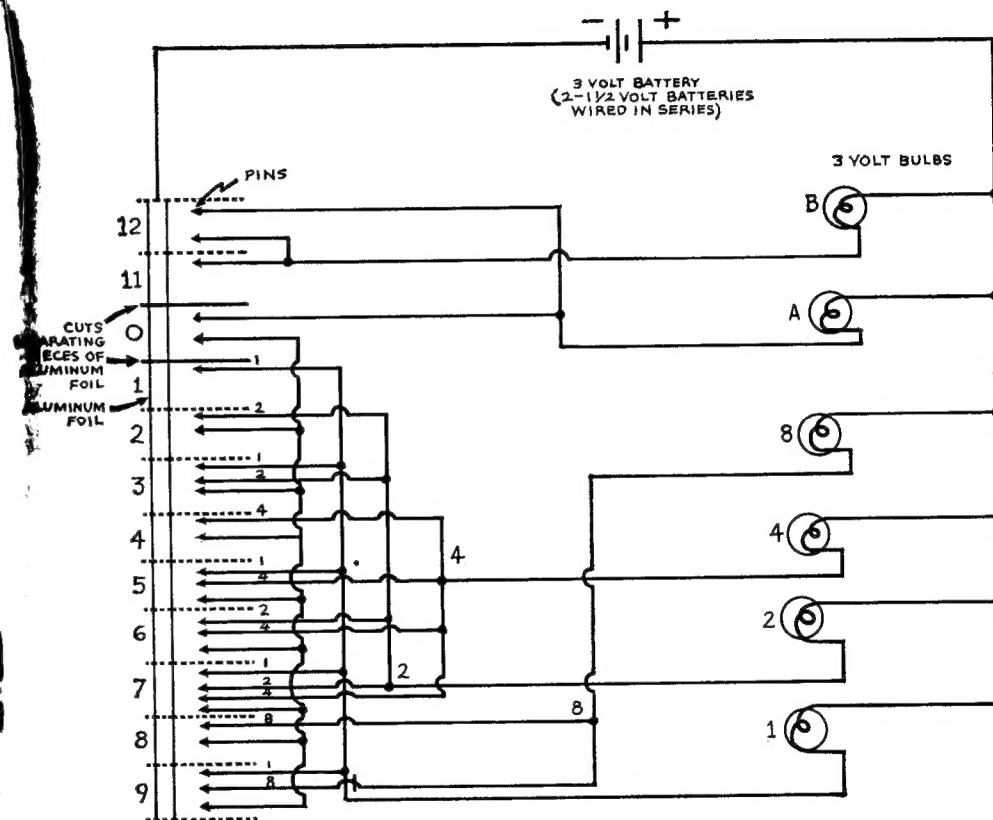To make the BSA card reader you will need:

- 10- by 10-inch piece of corrugated cardboard
- 10- by 4-inch piece of corrugated cardboard
- Masking tape
- Common straight pins
- 3-volt battery of two 1½-volt batteries wired in series
- 6 3-volt bulbs
- Aluminum foil
- Wire
- Solder and soldering iron
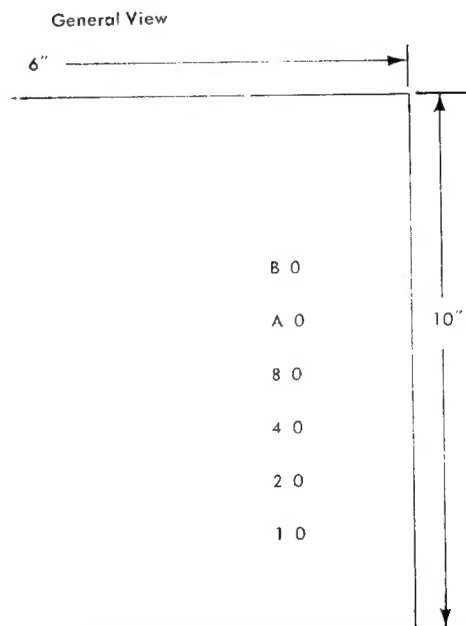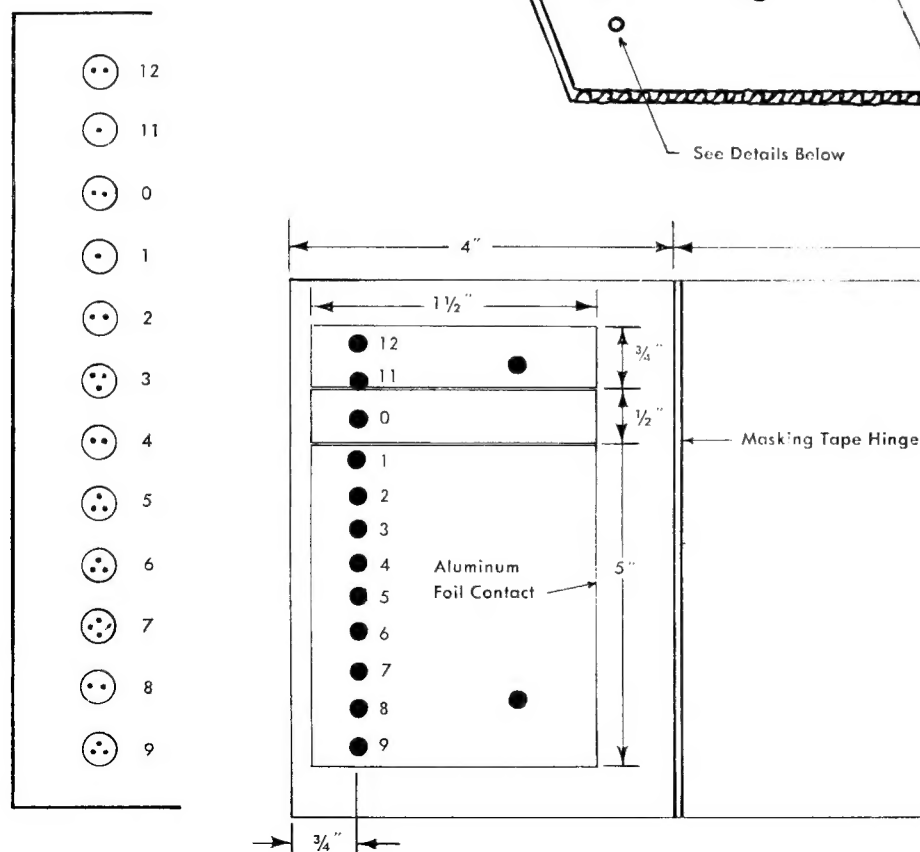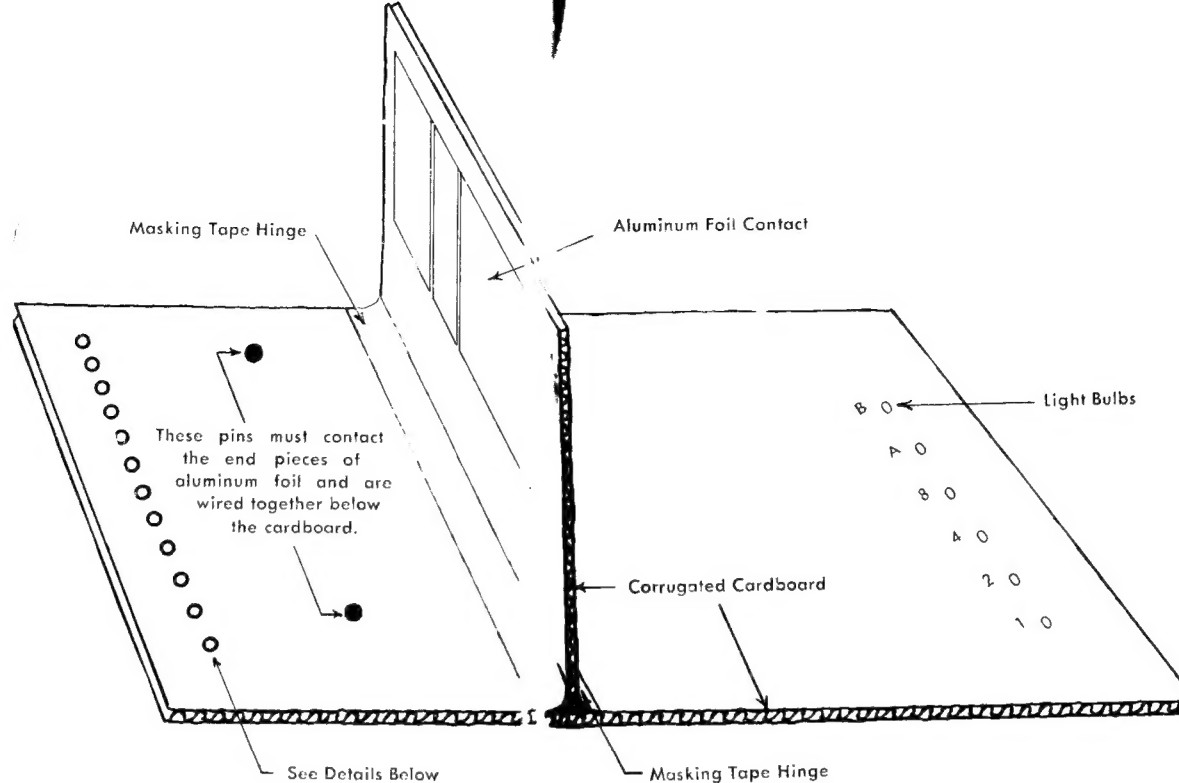- 5- by 8-inch index cards and a paper punch

Construction

The contacts on the card reader are straight pins pushed through the cardboard as shown on page 62. Each group of pins must fit within a ¼-inch circle but must not touch one another. The groups must be spaced a half inch apart as shown.

The bottoms of the pins are then soldered to wires leading to appropriate bulbs as shown on the circuit diagram on page 61.

Attach the aluminum foil contact to the smaller piece of cardboard as shown, with masking tape. When this hinged flap is lowered over a punched card, it will activate the circuits leading to appropriate light bulbs.

Right, the card reader is open to receive card. Photo above shows foil pressed against card. Punch holes let current through to light proper bulb.

Masking Tape Hinge

Aluminum Foil Contact

These pins must contact the end pieces of aluminum foil and are wired together below the cardboard.

Light Bulbs

B 0

A 0

8 0

4 0

2 0

1 0

Corrugated Cardboard

See Details Below

Masking Tape Hinge

General View

⊙⊙	12
⊙	11
⊙⊙	0
⊙	1
⊙⊙	2
⊙⊙	3
⊙⊙	4
⊙⊙	5
⊙⊙	6
⊙⊙	7
⊙⊙	8
⊙⊙	9

4"

6"

1½"

12
11

0

¾"

½"

Masking Tape Hinge

1
2
3
4
5
6
7
8
9

Aluminum Foil Contact

5"

10"

B 0

A 0

8 0

4 0

2 0

1 0

¾"

The punched cards used with the reader are 5- by 8-inch index cards. Punch holes in the proper places according to the Hollerith code (page 51) to make up the desired letters and numbers.

The rows and colums on the card must be a half inch apart so that they will correspond to the pin positions on the card reader. Holes must be large enough to allow the aluminum foil to contact the pins in that row when the card is put on the reader.

Punches 1 to 9 are represented in binary-coded decimal by the 1-2-4-8 lights. A 12 punch causes the B and A lights to come on; an 11 punch causes the B light to come on alone. An 0 punch causes the A light to come on alone.

Books About Computers

Recommended by the American Library Association's Advisory Committee to Scouting.

Computers at Your Service, Bernice Kohn, 1962.

A beginner's book on what the computer is, how it began, and how it is used.

Computers! From Sand Table to Electronic Brain, Allan Vorwald and Frank Clark, 1964.

Good coverage, in basic terms, of the major requirements for the Computers merit badge.

Computers — The Machines We Think With, D. S. Halacy, Jr.

A readable account of the development, basic theories, and operation of computers, with a survey of their uses today and possibilities for the future.

Electronic Brains, Rolf Lohberg and Theo Lutz, 1965.

In easy stages the authors explain the language, mechanism, and workings of computers.

I Can Learn About Calculators and Computers, Raymond G. Kenyon, 1961.

A brief history of methods of calculation, followed by illustrated instructions for making counting devices and computers with the simplest of tools.

Your Future in the Electronic Computer Field, Dause L. Bibby, 1962.

Requirements and career opportunities available, followed by lists of computer manufacturers, universities with computers, data-processing service centers, and a glossary.

Much of the periodical literature about computers is very technical and requires considerable knowledge of electronics. However, the Data Processing Management Association, 524 Busse Highway, Park Ridge, Ill. 60068, can furnish supplemental reading of nontechnical material about computers, mainly data-processing systems.

ACKNOWLEDGMENTS

YOU AND YOUR COUNSELOR

Your merit badge counselor is as important to you as a good coach is to an athlete. He is a real "pro" in his field; be sure to soak up all the knowledge and experience he can offer. This may be your only chance to learn from an expert in this subject. Make it count.